GENETIC EFFECTS INFLUENCING EGGER TRAITS FROM DIALLEL MATING SYSTEM

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THESIS

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to

my loving parents

Brajabidhu Sijakhombi

DECLARATION

I hereby declare that this thesis entitled "GENETIC EFFECTS INFLUENCING TOWER TRAITS FROM DIALLEL MATING SYSTEM" is a bonafide record of research work done by me during the course of research and that the thesis had not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship, or other similar title, of any other University or Society.

Mannuthy,
2-9-1983.

Rashbehari

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CERTIFICATE

Certified that this thesis entitled " GENETIC EFFECTS INFLUENCING EGGER TRAITS FROM DIALLEL MATING SYSTEM" is a record of research work done independently by Sri. K.Rashbehari Singh under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship, or associateship to him.

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INTRODUCTION

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The importance of developing strains of chicken adapted to the ecological niches prevailing in the country cannot be over-emphasized. Taking cognizance of this, systematic poultry breeding research programmes were initiated by Indian Council of Agricultural Research (ICAR), Government of India and other agencies. All India Co-ordinated Research Project on Poultry for Eggs was launched by ICAR to evolve strains/strain crosses of poultry with high egg production potential from the best available germplasm. In order to achieve the objective set out for the project, a number of good quality strains belonging to one or more breeds were procured both from within the country and from abroad.

In most of the breeding centres purebred selection schemes, based on part production records, are being carried out with the object of genetically improving the purebreds and to identify superior cross combinations for use in commercial poultry operations.

Performance of a breed/strain/line in a cross combination may be evaluated in terms of general and specific combining ability and maternal effects. There are various methods for estimating combining ability among crosses. The diallel mating system has been used extensively and advantageously as it gives the information on the performance of all the possible combinations/crosses of breeds/strains/lines simultaneously.

Three strains of White Leghorn viz., IWN, IWP and F were under intra-population selection at the All India Co-ordinated Research Project on Poultry for Eggs, Trichur Centre for the past two generations. The combining ability of these strains has not been tested so far. Therefore, the present investigation to cross these strains in a full diallel system was taken up with the following objectives:

1. To identify the promising combination with respect to the age at first egg, body weight at 20 and 40 weeks of age, egg production upto 280 days of age and egg weight at 38th week of age.

2. To assess the genetic effects influencing the above traits and thereby the efficiency of the selection system that is being currently followed.

3. To work out heterosis in the traits studied and to identify the combinations most suited for commercial exploitation.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

1. Age at first egg

Lerner (1945) studied nicking in relation to sexual maturity in single comb White Leghorn. From the data on 31 sets of sire and dam diallel matings he was unable to demonstrate statistically significant sire x dam interaction effects, indicating that nicking was not of major importance in influencing this trait.

In analysing three sets of diallel matings of White Leghorns, Hazel and Lamoreux (1947) observed evidence of only very little nicking effects on sexual maturity which were however not significant statistically. Influence of sex-linked gene effect was not observed.

Brunson and Godfrey (1951) concluded after a series of crossbreeding experiments for two successive years that cross-breeding did not result in consistent improvement of age at sexual maturity. Hutt and Cole (1951) making use of two strains of White Leghorn, reported that F_1 inter-strain hybrids, when compared to their intra-strain half sisters showed consistent influence of heterosis in lowering age at first egg.

Nutt and Cole (1952) observed in reciprocal diallel crosses of two improved non-inbred strains of White Leghorn that the hybrids began to lay about five days earlier in comparison to their purebred half-sisters. King and Bruckner (1952) reported from a diallel mating of different strains of Barred Plymouth Rock and Rhode Island Red a highly significant heterosis in age at first egg.

Bose et al. (1957) reported from cross-breeding experiments that the data on sexual maturity of the crosses did not stand critical examination, however, the average in no case suggested delayed maturity.

Kuit (1965) reported early sexual maturity but relatively high losses during laying period of White Leghorn x Rhode Island Red in reciprocal crossing of a White Leghorn strain and a Rhode Island strain. Wearden et al. (1965) estimated specific combining ability to be more important for sexual maturity than general combining ability in a diallel crossing of three White Leghorn and three Rhode Island Red 'closed flock' strains. In accounting for the total variability they opined that breed effects were of major importance.

Yoes (1966) reported from a diallel mating of 17 strains belonging to five breeds of chicken that variation in age at first egg was due mainly to reciprocal effects and to lesser extent to maternal effects.

Wearden et al. (1967) found general sex-linked effect and significant source of variation of residual reciprocal effects for age at first egg from a full diallel crossing experiment involving three White Leghorn and three Rhode Island Red strains. They also reported that strain crosses between breeds were superior to strain crosses within breeds for sexual maturity.

Firu et al. (1970) observed lower age at first egg by 3 to 4 weeks in Pearl Hybrid (line 7 x line 8) than the parental lines of Leghorn. Shul'tsene (1970) noted the age at first egg of the progeny of the lines 1, 2, 1 x 2 and 2 x 1 to be 159, 161, 177 and 173 days respectively.

Batra et al. (1974) observed earlier sexual maturity of the strain crosses than the purebred strains in a 5 x 5 diallel crossing experiment of five White Leghorn strains. There was significant general combining ability for age at sexual maturity.

Batra et al. (1975) reported the general combining ability for the age at first egg to be 3.5 per cent of the total variance in a partial diallel cross involving four White Leghorn strains and a Babcock strain. Specific combining ability was essentially zero. Kim *et al.* (1975) found significant general combining ability for age at first egg accounting for 5.14 per cent of the total variance from a diallel crossing experiment of four White Leghorn strains. Reddy and Mohapatra (1975) reported highly significant difference between genotypes for age at first egg from a 2 x 2 diallel experiment of two White Leghorn strains. Variance due to general combining ability was mostly important for age at sexual maturity.

Hanumaiah *et al.* (1976) observed significant difference in the age at first egg between the genetic groups in a crossing experiment involving White Leghorn male with White Leghorn and Rhode Island Red pullets. Considerable degree of heterosis was noticed for age at first egg.

Jain and Mohanty (1978) conducted complete diallel with four White Leghorn strains and variance due to general combining ability and specific combining ability were found to be significant.

Singh and Singh (1979) crossed four inbred lines of White Leghorn in a diallel pattern and the average age at sexual maturity of the incrosses was found to be

175.48 ± 2.34 days as compared to 191.80 ± 3.60 days in the inbreds. For age at sexual maturity; heterosis, general combining ability, specific combining ability, maternal effects and reciprocal effects were found to be significant.

Singh *et al.* (1980a) took out reciprocal crosses of IWI and IWH strains of White Leghorn and found the age at first lay of IWI x IWH birds was lower than that of the counterparts of reciprocal cross but the difference between the crosses was not significant.

Jain *et al.* (1981) observed, in a complete diallel involving four White Leghorn strains, a significant variance due to general combining ability for age at sexual maturity. Heterosis was noticed for all the crosses except in one.

2. Body weight at 20 and 40 weeks of age

Hazel and Lamoreux (1947) observed about five per cent variation in body weight due to maternal effects in three series of matings between the same group of hens and three different groups of males of White Leghorn. Evidence of sex-linked gene influence was not observed.

Brunson and Godfrey (1951) concluded after comparing the productive performance among crosses involving Rhode Island Red, Barred Plymouth Rock and Single Comb White Leghorn, that cross-breeding did not bring about consistent improvement in body weight. Hutt and Cole (1951) observed in a reciprocal crossing of two strains of White Leghorn that the F_1 inter-strain hybrids when compared to their intra-strain half sisters showed consistent influence of heterosis in improving body size.

Hutt and Cole (1952) reported, in reciprocal crosses of two improved non-inbred strains of White Leghorn for two years, that the hybrids weighed at maturity 101 g more in first year and 138 g in second year in comparison to their purebred half sisters. King and Bruckner (1952) observed from diallel mating of different strains of Barred Plymouth Rock and Rhode Island Red highly significant heterosis in growth rate and significant heterosis in body weight.

Nordskog and Ghostley (1954) observed by mating eight strains of four breeds in all possible combinations, that growth to eight weeks of age appeared to be the most consistent expression of hybrid vigour. The strain crosses and the crossbred pullets averaged four per cent and seven per cent heavier than the pure strains at this age. Adult body weight of strain crosses and crossbreds was almost five per cent greater than pure strains.

Nordskog (1956) obtained statistically significant differences between reciprocal crosses for body weight of pullets at eight weeks of age in diallel crossing involving four strains of Leghorn, three heavy breeds and an Egyptian breed (Fayoumi).

Hill (1959) observed the percentage of total inter-cross genetic variation for general combining ability, specific combining ability and reciprocal effects for adult body weight as 81.6, 4.1 and 14.3 respectively in diallel crosses from seven inbred lines. The variance due to general combining ability and reciprocal effects were statistically significant.

Yao (1960) observed significant line effect between inbred lines of different breeds for 10 weeks body weight in a '4 x 4' diallel cross. Highly significant dominance effect in the crosses of all the inbred lines was also recorded. Moderate maternal effect was found only in the crosses of inbred lines of different breeds. For mature body weight significant line effect appeared in the crosses of inbred lines of different breeds and there was no dominance and maternal effects.

Hale and Clayton(1965) observed consistent reciprocal differences between crossbreds in pullet weight at 18 weeks in a six year study of the diallel crosses of Light Sussex and Brown Leghorn. Some significant interactions were noted in egg weight and pullet weight. Kuit (1965) reported lighter weight of Rhode Island Red x White Leghorn cross than the reciprocal cross at 500 days of age (2160 g-2290 g) in a reciprocal crossing of a White Leghorn strain and a Rhode Island strain. Wearden _et al._ (1965) observed the general combining ability to be much more important than specific combining ability for five and ten month body weight in a diallel mating of three White Leghorn and three Rhode Island Red 'closed flock' strains. Maternal effects were relatively important in determining five month body weight. In accounting for the total variability that could be explained breed effects were of major importance.

Yoes (1966) reported from a diallel mating of 17 strains of five breeds of chicken that reciprocal effects were very important in determining body weight of female egg type chickens. Most of the specific and maternal effect estimates were negative and thus assumed to be zero.

Sergyeyev _et al._ (1973) observed differences in body weight attributable to specific combining ability in a combination of five Russian White male lines with two New Hampshire and one Rhode Island Red female lines.

Sergeev and Sergeeva (1973) found no heterosis for body weight in line crosses as well as breed crosses.

Batra *et al.* (1974) observed significantly higher average body weights at 6, 12, 18 and 24 weeks of age by 1.4 - 5.6 per cent in the strain crosses than the purebred strains from a '5 x 5' diallel crossing experiment of five White Leghorn strains. Specific combining ability was largest for body weight at 6 and 12 weeks. Eftimov *et al.* (1974) observed higher body weight at 150 days of age of line cross females than the linebred females in a '2 x 2' diallel crossing of White Leghorn lines 5A and 6E.

Batra *et al.* (1975) found the general combining ability of body weight at sexual maturity to be 13 per cent of the total variance in a restricted diallel cross involving four White Leghorn strains and a Babcock strain. Specific combining ability was essentially zero. Kim *et al.* (1975) observed significant general combining ability for body weight at three ages accounting for 8.55 per cent, 5.97 per cent and 3.30 per cent of the total variance in a diallel crossing experiment of four White Leghorn strains. Maternal effects for body weight at three ages were significant verying from 3.87 to 8.93 per cent of the total variance. There was significant sex-linked effects for eight weeks weight accounting for 2.96 per cent of the total variance. Reddy and Mohapatra (1975) reported highly significant differences between genotypes for body weights at twenty and forty weeks of age in a '2 x 2' diallel mating of two White Leghorn strains. Variance due to general combining ability was mostly important for forty weeks body weight.

Hanumaiah et al. (1976) found significant differences in body weight between the genetic groups in a crossing experiment involving White Leghorn male with White Leghorn pullets and Rhode Island Red pullets. There was absence of heterosis for body weight at later ages (10 weeks body weight and body weight at first egg) when compared to the early age (8 weeks body weight).

Das et al. (1978) observed significant general combining ability and reciprocal effects for body weight at 30 and 40 weeks of age in a diallel mating involving four White Leghorn strains. General combining ability accounted for 46.13 and 32.61 per cent respectively of the variation in body weight at 30 and 40 weeks of age and reciprocal effects for 21.69 and 28.59 per cent.

Jain and Mohanty (1978) conducted complete diallel with four White Leghorn strains and the variance due to reciprocal effects was significant for body weight. Variance due to general combining ability and specific combining ability were not significant.

Singh and Singh (1979) crossed four inbred lines of White Leghorn in a diallel pattern and the average body weight at sexual maturity was found to be 1477.27 ± 51.62 g as compared to 1326.30 ± 40.95 g of the inbred. Heterosis was in a positive direction and there was an average gain in body weight by 151 g.

Jain et al. (1981) performed a complete diallel cross involving four White Leghorn strains and found significant general combining ability and reciprocal effects for body weight at 21st week of age. Heterosis could be observed only for two crosses.

Kovalenko et al. (1982) observed from a diallel crossing of White Leghorn line D-21, the local type of Poltava Clay, Rhode Island Red line 20 and mini hens, the existence of additive genetic effects on body weight at 12 months of age. The Rhode Island line showed the greatest general combining ability for body weight.

3. Egg production upto 280 days of age

Hutt and Cole (1951) observed in reciprocal crosses between two strains of White Leghorn that the F_1 inter-strain hybrids when compared with their intra-strain half sisters showed consistent influence of heterosis in raising egg production.

Hutt and Cole (1952) found in reciprocal diallel crosses of two improved non-inbred strains of White Leghorn that the hybrids laid more eggs in comparison with their purebred half sisters. King and Bruckner (195[illegible]) reported from diallel mating of different strains of Barred Plymouth Rock and Rhode Island Red, highly significant heterosis in egg production. A possible sex-linked effect was also demonstrated for egg production since the Barred crosses were so consistently superior to the other matings used.

Nordskog and Ghostley (1954) observed by mating eight strains of four breeds of chicken in all possible combinations that the strain crosses and crossbreds exceeded the pure strains by 10 per cent and 12 per cent in total egg production.

Nordskog (1956) observed that the egg production of the heavy male x Leghorn female crosses exceeded their reciprocals by 10 per cent in diallel crossing involving four strains of Leghorns, three heavy breeds and an Egyptian breed.

Goto and Nordskog (1959) observed statistically significant sire-line and dam-line differences from inbred line diallel crosses of White Leghorns for 165, 269 and 300 days hen-housed per cent egg production and hen-day total egg production. They found that general combining ability was more important than specific combining ability for the traits considered. Hill (1959) observed the percentage of total intercross genetic variation for general combining ability, specific combining ability and reciprocal effects for hen-day egg production as 62.9, 2.9 and 34.2 respectively in diallel crosses from seven inbred lines. The variance due to general combining ability and reciprocal effects were statistically significant.

Yao (1960) found highly significant line and maternal effects for egg production and egg production rate in a '4 x 4' diallel cross.

Sergeev and Sergeeva (1964) got average egg production of 220 eggs with an average egg weight of 54 - 56 g in the crossbreds, obtained by crossing egg producing line averaging

214 eggs and the egg weight line averaging 204 eggs with an average weight of 60.1 g. of Russian Whites.

Hale and Clayton (1965) reported a degree of heterosis in averages of egg production in a six year study of the diallel crosses of Light Sussex and Brown Leghorn. They concluded that reciprocal recurrent selection would not have been advantageous for improving egg production of crossbreds from the two flocks. Wearden et al. (1965) estimated specific combining ability to be more important for hen-day and hen-housed egg production to 260 and 470 days of age than general combining ability in a diallel crossing of three White Leghorn and three Rhode Island Red 'closed flock' strains. In accounting for the proportion of the total variability that could be explained, strain effects were of major importance for hen-day per cent production.

Wearden et al. (1967) found general sex-linked effect for part year hen-housed egg production in a full diallel crossing experiment involving three White Leghorn and three Rhode Island Red strains.

Firu et al. (1970) observed higher monthly egg production upto 85 per cent and intensity of laying upto 51 per cent in the Pearl hybrids (line 7 x line 8) than in the parental lines of Leghorn. Kadura (1970) reported greatest heterosis in D x A, D x U and D x Local crossbreds for egg production to 12 months of age compared to that of the male and female parental lines, the production being raised by 12.2 and 13.1 per cent, by 11.2 and 13.0 per cent and by 2.7 and 24.3 per cent respectively for the three crossbred groups from a crossing experiment involving Leghorn lines A, D and U imported from Japan and with local Poltava fowls.

Polyanichkin (1971) observed the crossbreds 95 x B to be the highest egg producer at the beginning of lay producing 34.0 and 33.8 per cent more than the parental lines respectively from a diallel crossing of lines B and G of Moscow breed groups and lines 95 and 103 of the Russian White breed. The 500 day egg production of the 108 x G crossbreds was highest (212.6) and exceeded that of the parental lines by 29.2 and 31.5 per cent respectively. Sergeev and Sergeeva (1971) found the 12 months egg production of the line cross hybrids of Russian White sire line 108 and the Russian White dam line 106 to be 237 as against 204 and 194 respectively of the parental lines. Singh and Singh (1971) compared the various types of crosses of White Leghorn and Rhode Island Red. Maximum egg production was obtained from strain crossing followed by top crossing and top crossbreds. The strain crosses were superior to purebreds as well as other types of crossbreds.

Sergeev et al. (1972) observed in diallel reciprocal matings between birds of three lines selected for egg production and two lines selected for high egg weight the effect of type of cross and locations and their interactions to be significant in respect of egg production. There was significant general combining ability and the differences between reciprocal crosses were significant for egg production. Sergycyev et al. (1972) found considerable differences in egg production due to general combining ability in a combination of five Russian White male lines with two New Hampshire and one Rhode Island Red female lines.

Sergeev and Sergeeva (1973) reported 15 - 30 per cent heterosis for egg production in a crossing experiment. Shkredov et al. (1973) also found heterosis for egg production in a crossing experiment involving eight strains of White Leghorn.

Batra et al. (1974) observed 0.8 - 6.5 per cent more egg production in the crosses than the pure strains in a '5 x 5' diallel crossing experiment of White Leghorns.

There was significant general combining ability for egg production. Eftimov et al. (1974) reported significantly higher egg production in the line cross females than the line bred females in a 2 x 2 diallel mating experiment involving line 5A and line 6E.

Batra et al. (1975) found the general combining ability for egg production to be 2.5 per cent of the total variance in a partial diallel cross involving four White Leghorn strains and a Babcock strain. Specific combining ability was essentially zero. Kim et al. (1975) observed significant general combining ability for egg production percentage and egg number to 500 days of age to be 10.29 and 7.99 per cent of the total variance respectively from a diallel crossing experiment of four White Leghorn strains. There were significant maternal effects for egg production percentage and 500 day egg production accounting for 2.37 per cent and 7.82 per cent of the total variance respectively. Orozco and Campo (1975) reported heterotic effect for egg laying rate in the crossbreds in a diallel crossing experiment of two White Leghorn strains. Reddy and Mohapatra (1975) found highly significant differences between genotypes for egg production from a diallel mating of two White Leghorn strains. The variance due to specific combining ability and reciprocal effects were very high as compared to general combining ability for egg production.

Hanumaiah *et al.* (1976) reported significant differences in egg production between the genetic groups in a crossing experiment involving White Leghorn male with White Leghorn and Rhode Island Red pullets. There was considerable degree of heterosis for egg production.

Jackunes *et al.* (1977) observed in a diallel crossing experiment involving Dutch Leghorn lines significant but small general and specific combining ability for egg production to 72 weeks of age. Dam line accounted for 66 per cent of the general combining ability.

Benjamine and Choudary (1978) reported that strain combinations obtained from a modified diallel cross using three strains of White Leghorns were in general, superior for egg number to a leading commercial stock. Das *et al.* (1978) found significant general combining ability and reciprocal effects for egg production from 181 to 340 days of age in a diallel mating involving four White Leghorn strains. General combining ability and reciprocal effects accounted for 23.05 and 29.62 per cent of the variation in egg production.

Jain and Mohanty (1978) conducted complete diallel mating making use of four White Leghorn strains and reported that the variance due to general combining ability, specific combining ability and reciprocal effect were significant for egg production.

Singh and Singh (1979) crossed four inbred lines of White Leghorn in a diallel way and the average 90 days egg production of the incrosses was found to be 60.91 ± 1.79 eggs as compared to 40.71 ± 2.67 eggs of the inbreds. Effects due to heterosis and sex-linked effects were found to be significant.

Jain _et al._ (1981) conducted a complete diallel mating involving four White Leghorn strains and found significant general combining ability and reciprocal effects for egg production upto 280 days of age. Heterosis was observed in all the crosses except two.

Kovalenko _et al._ (1982) reported from a diallel crossing of White Leghorn line B21, the local type of Poltava Clay, Rhode Island Red line 20 and mini hens, the existence of dominance or overdominance for egg production upto 500 days of age.

4. Egg weight

Waters (1945) observed from mating of 28 unrelated sires and 14 unrelated dams (3 of the dams had a half-sib relationship) of White Leghorn that maternal effect was predominant for egg weight inheritance and any genetic influence of the paternal parent was insignificant.

Brunson and Godfrey (1951) concluded after comparing the productive performance among Rhode Island Red, Barred Plymouth Rock, Single Comb White Leghorn, F_1 progeny of Rhode Island Red x Barred Plymouth Rock (Black cross pullets) and F_1 progeny of Single Comb White Leghorn x Black cross pullets for two successive years that with the strains involved cross-breeding did not result in consistent improvement of egg weight. Hutt and Cole (1951) reported that F_1 inter-strain hybrids when compared with their intra-strain half sisters showed consistent influence of heterosis in raising egg weight.

Hutt and Cole (1952) further observed from reciprocal diallel crosses of two improved non-inbred strains of White Leghorn that the hybrids laid bigger eggs (by 2-3 g) in comparison to their purebred half-sisters. King and Bruckner (1952) observed in diallel mating of different strains of Barred Plymouth Rock and Rhode Island Red no evidence of heterosis. There was a significant sire effect on egg weight which suggested that sex-linkage was a factor in the inheritance of egg weight in the particular strains used.

Osborne (1953) opined by analysing mean March egg weight within a line of Brown Leghorn that sex-linked inheritance may be operative for egg weight.

Nordskog and Ghostley (1954) reported from a mating involving eight strains of four breeds in all possible combinations that the crosses had no influence on egg weight.

Goto and Nordskog (1959) found statistically significant sire-line and dam-line differences in egg weight from inbred line diallel crosses. They reported that general combining ability was more important than specific combining ability for egg weight. Hill (1959) obtained the percentage of total intercross genetic variation for general combining ability, specific combining ability and reciprocal effects for egg weight as 43.5, 42.9 and 13.6 respectively in diallel crosses from seven inbred lines. Variance due to general combining ability and specific combining ability were statistically significant.

Yao (1960) observed significant line effect and moderately significant dominance effect for egg size from a '4 x 4' diallel crossing experiment.

Redman and Shoffner (1961) found the general combining ability, specific combining ability and reciprocal effects for egg weight to be over 60 per cent, 10 per cent and 30 per cent respectively in a polyallel cross of five lines. They had shown that the additive variance in between cross analysis and dominance variance a major source in the within cross analysis.

Sergeev and Sergeeva (1964) reported an average egg production of 220 eggs with an average egg weight of 54 - 56 g in the crossbreds, obtained by crossing egg producing line averaging 214 eggs and the egg weight line averaging 204 eggs with an average weight of 60.1 g, of Russian Whites.

Hale and Clayton (1965) obtained consistent reciprocal differences between crossbreds in egg weight in a six year study of the diallel crosses of Light Sussex and Brown Leghorn. Some significant interactions were noted in egg weight and pullet weight.

Yoes (1966) reported from a diallel mating involving 17 strains of five breeds of chicken that all estimates for specific combining ability for egg weight were negative.

Shul'tsene (1970) reported the egg weight of the progeny of the lines 1, 2, 1 x 2 and 2 x 1 to be 54.6, 55.9, 55.4 and 55.6 respectively.

Sergyeyev *et al.* (1972) found considerable differences in egg weight due to general combining ability in a combination of five Russian White male lines with two New Hampshire and one Rhode Island Red female lines.

Sergeev and Sergeeva (1973) found no heterosis for egg weight in the following crosses : 2 and 3 line crosses involving nine Russian White Lines, 2 and 3 crosses involving four White Leghorns, interbreed crosses involving Russian White, Rhode Island Red and New Hampshire. Shkredov *et al.* (1973) reported no heterosis for egg weight.

Batra *et al.* (1974) observed heavier eggs in the strain crosses than the purebred strains in a '5 x 5' diallel crossing experiment of five White Leghorn strains. There was significant general combining ability for egg weight. Eftimov *et al.* (1974) found highly significant higher egg weight in the line cross females than the line bred females in a diallel crossing experiment involving lines 5A and 6B.

Batra *et al.* (1975) reported the general combining ability for egg weight to be 10 per cent of the total

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variance in a partial diallel cross involving four White Leghorn strains and a Babcock strain. Specific combining ability was essentially zero. Kim *et al.* (1975) observed significant general combining ability for egg weight accounting for 10.41 per cent of the total variance in a diallel crossing experiment involving four White Leghorn strains. There was significant maternal effect for egg weight accounting for 2.58 per cent of the total variance.

Orozco and Campo (1975) observed heterotic effect for egg weight in the crossbred in a diallel crossing experiment of two White Leghorn strains. Reddy and Mohapatra (1975) reported highly significant differences between genotypes for egg weight in a '2 x 2' diallel crossing experiment involving two White Leghorn strains. Variance due to general combining ability was mostly important for egg weight.

Hanumaiah *et al.* (1976) found significant differences in egg weight between the genetic groups in a crossing experiment involving White Leghorn males with White Leghorn and Rhode Island Red pullets. No heterosis was observed for egg weight.

Pohar *et al.* (1977) reported from a diallel test involving five inbred egg-type White Leghorn lines that the specific combining ability was greater for egg weight than general combining ability.

Jain and Mohanty (1978) conducted complete diallel with four White Leghorn strains and reported that variance due to general combining ability, specific combining ability and reciprocal effect was significant for egg weight.

Luk'yanova and Burdashkina (1979) reported from a reciprocal mating of White Leghorn line K-63 and Poltava Clay lines R and P-37 that the egg weight ranged from 55.1 to 58.3 g, the heaviest eggs coming from K-63 females. The effect of dam breed on egg weight to seven months of age was significantly greater than the effect of sire breed. Heterosis for egg weight ranging from 0.8 to 7.8 per cent was apparent only in the first two months of lay. Egg weight at 270 days of age was significantly correlated with that at 490 days.

Singh et al. (1980b) conducted a full diallel crossing experiment involving four egg laying strains of poultry and found that general combining ability and specific combining ability for egg weight and thereby additive and non-additive gene action were important.

Jain et al. (1981) conducted a complete diallel cross involving four White Leghorn strains and reported significant general combining ability and reciprocal effects for egg weight. Heterosis was evident in eight out of 16 crosses.

Kovalenko et al. (1982) reported the existence of additive genetic effects on egg weight at 500 days of age from a diallel experiment and also observed that the Rhode Island Red line showed the greatest general combining ability for this trait.

MATERIALS AND METHODS

MATERIALS AND METHODS

Data collected from a full diallel mating involving IWN, IWP and F strains of White Leghorn maintained at the Trichur Centre of the All India Co-ordinated Research Project on Poultry for Eggs formed the material for the study.

1. Geographical location and climate of the Research Station

The All India Co-ordinated Research Project (AICRP) on Poultry for Eggs, Trichur centre is located at a latitude of 10.32°N and longitude of 74.20°E. It is situated at an altitude of 22.25 m above the mean sea level. The main climatic feature of the place is that it is blessed with both the South West and North East monsoons. The mean annual temperature is 27.2°C and the relative humidity is 74.19 per cent. The mean annual rainfall is 3034.9 mm.

2. History of the flock

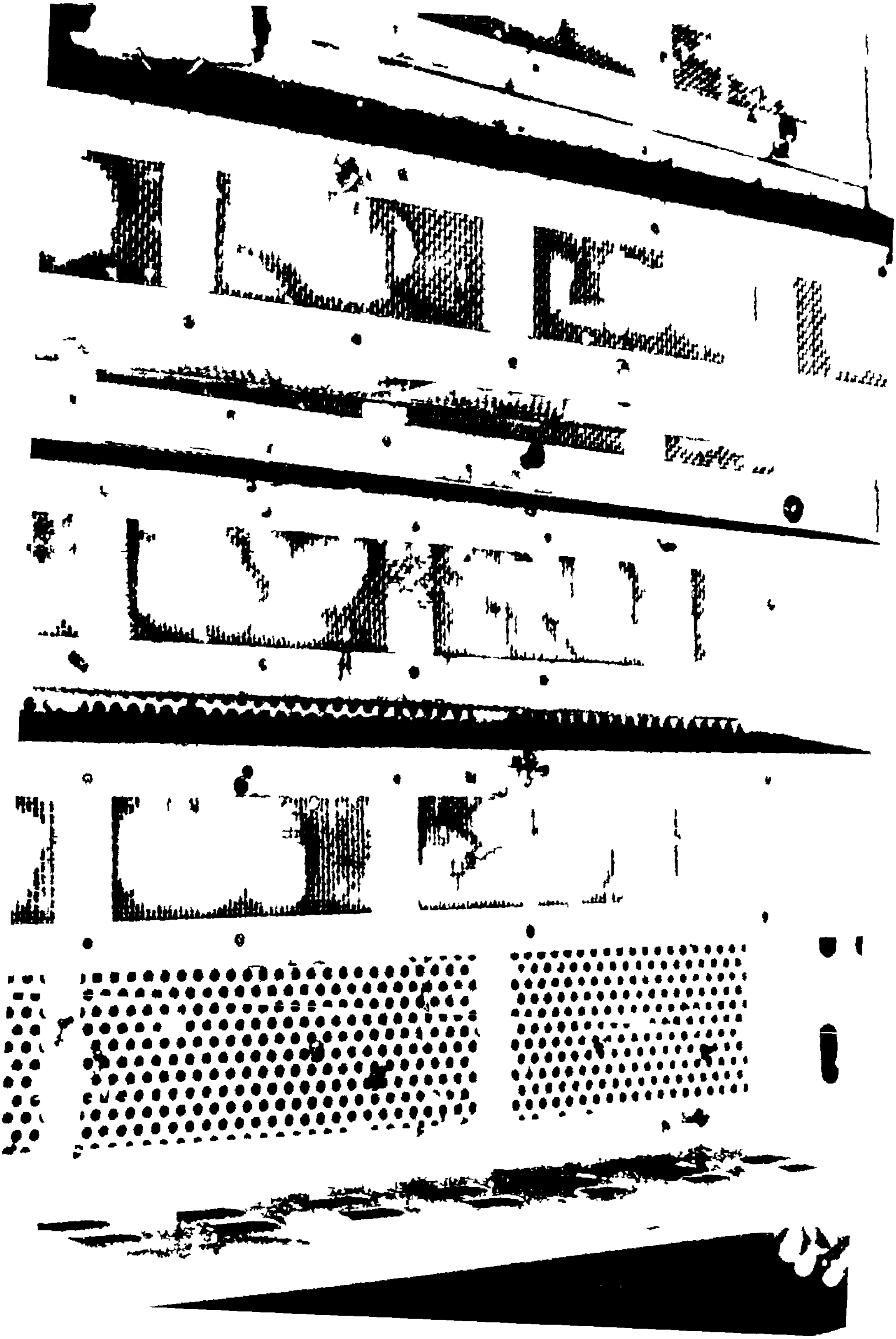
IWN and IWP strains were imported by Government of India in early seventies. The F strain was available in the University Poultry Farm, Mannuthy. They were procured for the AICRP on Poultry for Eggs in the year 1978 for initiation of a large poultry breeding programme at this location.

During the past years, selection for partial egg production upto 280 days of age was practised in these strains using an index constructed by Osborne (1957a,b).

3. Mating plan

In all, 60 single mating pens were used for generating the experimental chicks. These 60 pens were equally divided among the three strains. Thus, 20 pens were headed by sires belonging to IWN strain, another 20 pens by IWP strain and the remaining 20 by F strain. To each pen, three pullets belonging to IWN, IWP and F strains were randomly assigned. Thus each male sired nine females (three females each belonging to the three strains). The chicks belonging to nine genetic groups were pedigree hatched (Fig. 1). Chicks were sexed while taking out the hatch and only the female offspring were retained for the study.

The pullets were housed in a replicated trial and the allotment of pens to different genetic groups and replicates were at random. The number of pullets in different groups



were as follows:

Sire strain \ Dam strain	IWP	IWN	F
IWP	75	63	77
IWN	80	81	76
F	73	79	85

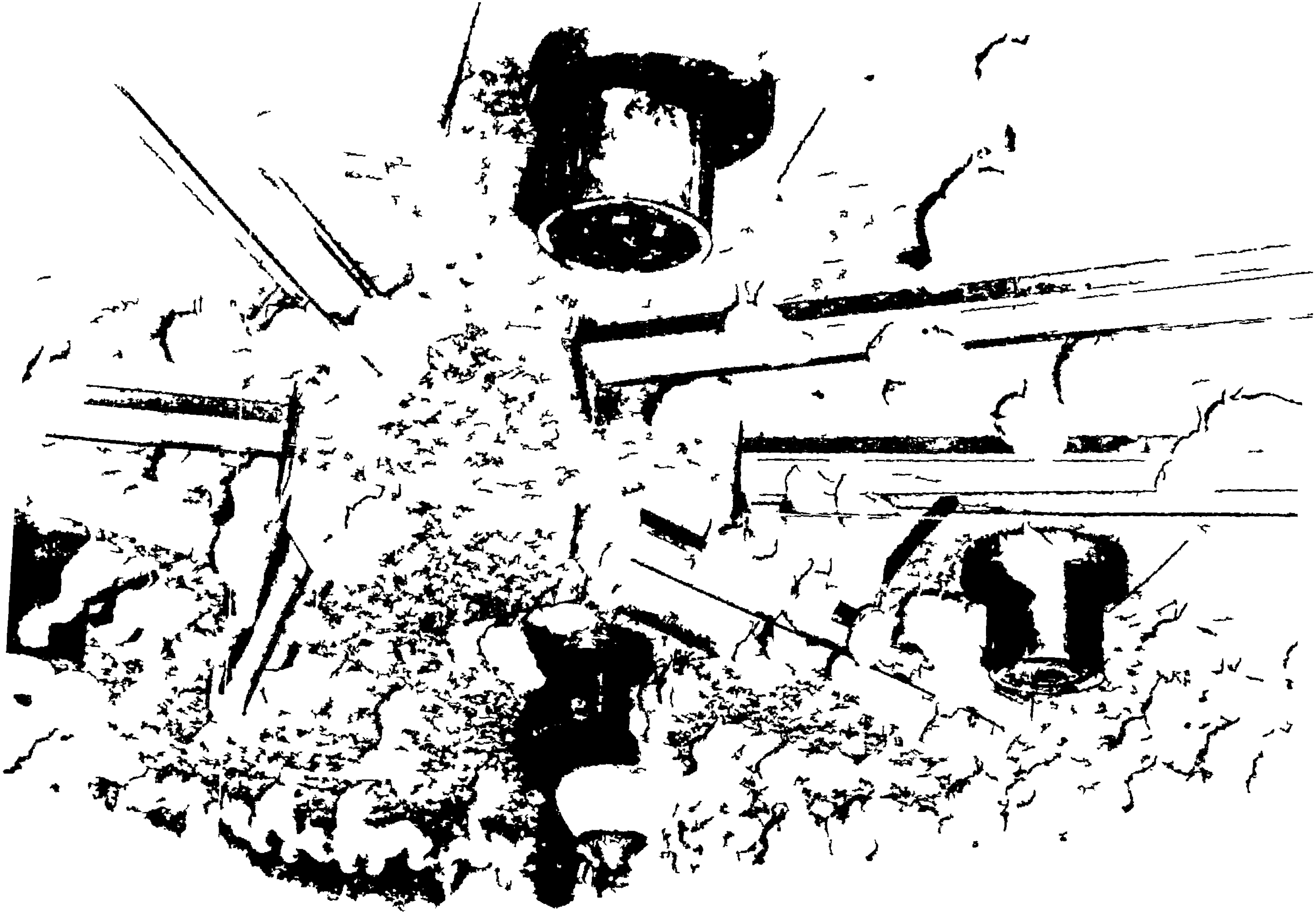
In a cross combination, the first strain indicates the sire strain and the second the dam strain throughout the text.

4. Management

The nutrition, health and management practices were kept as identical as possible for all the genetic groups throughout the experimental period (Fig.). The proximate composition of the ration fed to the birds is as follows

<u>Chemical composition of the layer mash (on dry matter basis)</u>.

Nutrient	Per cent content
Dry matter	94.9
Crude protein	[illegible]



Chemical composition of the layer mash (on dry matter basis).
contd.......

Nutrient	Per cent content
Ether extract	3.2
Crude fibre	7.0
Nitrogen free extract	53.9
Total ash	17.9
Acid insoluble ash	4.4
Calcium	3.17
Phosphorus	1.37

All the birds were raised on deep litter throughout the experimental period.

5. Measurement of traits

The traits measured were age at first egg, body weight at 20 and 40 weeks of age, egg production upto 280 days of age and egg weight at 38 weeks of age.

a) Age at first egg.

This was obtained by deducting the date of hatch from the date of first egg for each pullet and the average was computed in days.

b) Body weight.

Individual body weight to the nearest 10 g was recorded at 20 and 40 weeks of age.

c) Egg number.

The eggs laid by each bird upto 280 days of age was recorded using trapnest.

d) Egg weight.

At 38 weeks of age, the weight of 24 eggs picked at random was measured to the nearest 0.1 g for each genetic group (12 eggs per replicate) and their mean weight was computed.

6. Statistical Method

a) Preliminary analysis.

The data classified according to different genetic groups were analysed preliminarily to investigate genotypic differences if any, for the traits considered. The mathematical model assumed for the analysis was:

$$Y_{ij} = \mu + G_i + e_{ij}$$

where Y_{ij} = the j^{th} observation of the i^{th} genetic group

μ = the overall mean

G_i = the effect of the i^{th} genetic group

e_{ij} = random error assumed to be NID $(0, \sigma^2 e)$

b) Genetic analysis.

Since the data were disproportionately distributed among the various subclasses, the method of fitting constants by least squares as outlined by Harvey (1975) was carried out. The model used for analysis is as follows:

$$Y_{ijk} = \mu + s_i + d_j + (sd)_{ij} + e_{ijk}$$

where Y_{ijk} = the observation on the K^{th} offspring of a mating between the j^{th} dam and the i^{th} sire strain.

μ = the population mean

s_i = the effect of the i^{th} strain when used as a sire strain

d_j = the effect of the j^{th} strain when used as a dam strain

$(sd)_{ij}$ = the interaction between sire and dam strains

e_{ijk} = random error assumed NID $(0, \sigma^2 c)$

The two-way analysis with interaction is summarised below:-

Source of Variation	df	SS	MS
Between sire strains	2	SS_s	MS_s
Between dam strains	2	SS_D	MS_d
Interaction between sire and dam strains	4	SS_E	MS_e
Error	$n_{..} - 9$		

This analysis of the two-way classification with interaction yield a measure of the overall performance of the strains as sire and dam. If significant interaction of sires and dams, was present, the concern was only about the performance of particular crosses produced in the experiment rather than about the value of the strain as sires and dams. The interaction might result from significant specific combining ability and residual reciprocal effect.

Test for significance of overall performance of the strains as sire and dam lines.

When, between the sire and the dam strain variations were found significant by 'F' test, the strains were ranked according to their performance as sire and dam lines respectively and the differences were tested for significance using 't' test.

$$t = \frac{C_i - C_j}{\sqrt{(C_{ii} + C_{jj} - 2\ C_{ij})\quad MS_E}}$$

may be compared with critical value t_α, error df.

where $C_i - C_j$ is the difference between the performance of the i^{th} and j^{th} strain as sire and dam line.

$\sqrt{(C_{ii} + C_{jj} - 2\ C_{ij})\ MS_E}$ is the standard error of the difference

C_{ii} and C_{jj} are the corresponding diagonal inverse elements of the constants.

C_{ij} is the inverse element corresponding to i^{th} row and j^{th} column.

MS_E is the mean square of error.

<u>Estimation of heterosis and test for their significance.</u>

A significant sire x dam interaction is indicative of the presence of hterosis and/or residual reciprocal effects. The amount of heterosis was determined as the deviation of the average of the reciprocal crosses from that of the parents which were deployed for obtaining the crosses.

The residual reciprocal effects were estimated as the difference between the reciprocal crosses. The necessary contrasts for estimating them were arranged in the form of a transformation matrix (K). The estimation of heterosis (h_{ij}), the residual reciprocal effects (r_{ij}) and necessary quantities required to test their significance were derived using the transformation matrix, the sub-class means for the nine genetic groups and the reciprocals of the subclass numbers.

The test statistics $F = \frac{(qk)^2}{(C_{qk\ qk})MS_E}$ may be compared with critical value $F_{\alpha, 1, \text{error df}}$. The estimate to be tested is qk ie $h_{IWP \times IWN}$, $h_{IWP \times F}$, $r_{IWP \times IWN}$ etc. $C_{qk\ qk}$ is the relevant inverse element. For instance to test $h_{IWP \times IWN}$, the inverse element required is $C_{h_{IWP \times IWN}\ h_{IWP \times IWN}}$. MS_E is the mean squares of error. The quantity $(q^2 k/C_{qk\ qk})$ is the mean square for the estimate and it has one degree of freedom.

RESULTS

RESULTS

1. Means and Standard Errors and Phenotypic Analysis

The data pertaining to age at first egg, body weight at 20 and 40 weeks of age, egg production upto 280 days of age and egg weight at 38 weeks of age are set out in table 1 to 5.

i) Age at First Egg.

The means and standard errors of age at first egg are presented in table 2. Among the purebreds, F strain registered 176.95 ± 2.16 days as the age at first egg which was the lowest. On the contrary IWN strain attained sexual maturity only by 186.23 ± 4.78 days which was the highest, whereas the corresponding figure for IWP strain was 182.49 ± 1.73 days.

Among the cross combinations, F x IWP combination attained sexual maturity by 176.69 ± 2.30 days which was the lowest among the nine genetic groups studied. The reciprocal cross attained sexual maturity by 179.58 ± 1.78 days which was the second lowest among all the genetic groups considered. IWN x IWP combination attained sexual maturity by 181.51 ± 2.15 days whereas its reciprocal attained only by 190.01 ± 2.24 days. F x IWN combination registered 181.51 ± 2.01 days whereas its reciprocal attained maturity by 180.45 ± 2.21 days.

Table 1. Means and standard errors of age at first egg (days) for the 3 x 3 diallel cross

Sire strain \ Dam strain	I W P	I W N	F
IWP	182.4928±1.7281 (69)	190.0306±2.2390 (62)	179.5775±1.7796 (71)
IWN	181.5068±2.1543 (73)	186.2797±4.7855 (74)	180.4462±2.21[illegible]5 (65)
F	176.6957±2.3037 (69)	181.5132±2.0599 (76)	176.9524±[illegible].1641 (84)

Figures in parenthesis indicate sample size.

Table 2. Means and standard errors of body weight (g) at 20 weeks for 3 x 3 diallel cross

Sire strain \ Dam strain	I W P	I W N	F
IWP	1152.0290± 14.8831 (69)	1121.6418± 17.6869 (67)	11[illegible]4.5946± 20.8920 (74)
IWN	1[illegible]38.8158± 12.1750 (76)	1219.5584± 12.7539 (77)	1143.6486± 14.667[illegible] (74)
F	11[illegible]4.1176± 13.4309 (68)	1121.0390± 12.6828 (77)	1113.125[illegible]± 9.0368 (80)

Figures in parenthesis indicate sample size.

Table 3. Means and standard errors of body weight (g) at 40 weeks for the 3 x 3 diallel cross

Sire strain \ Dam strain	I W P	I W N	F
IWP	1628.5714 ± 23.9931 (63)	1536.1538 ± 22.3137 (52)	1567.7941 ± 22.5686 (68)
IWN	1654.8387 ± 27.0317 (62)	1585.5072 ± 21.0068 (69)	1493.2[illegible]03 ± 21.3669 (59)
F	1605.0725 ± 23.4754 (69)	1532.5758 ± 18.3086 (66)	1531.7073 ± 17.2986 (92)

Figures in parenthesis indicate sample size.

Table 4. Means and standard errors of egg number for the 3 x 3 diallel cross

Sire strain \ Dam strain	I W P	I W N	F
IWP	73.5238 ± 2.0199 (63)	66.4107 ± 2.9560 (56)	80.4394 ± 2.0881 (66)
IWN	72.2222 ± 2.7954 (63)	72.0735 ± 2.5300 (68)	73.8167 ± 2.9107 (60)
F	80.7101 ± 2.0780 (69)	77.3636 ± 2.7320 (66)	84.2346 ± 2.1106 (81)

Figures in parenthesis indicate sample size.

Table 5. Means and standard errors of egg weight (g) for the 3 x 3 diallel cross

Sire strain \ Dam strain	I W P	I W N	F
IWP	53.1500±0.5277 (24)	51.0833±0.6867 (24)	53.9167±0.7706 (24)
IWN	55.2708±0.7626 (24)	55.0000±0.6138 (24)	52.4167±0.8185 (24)
F	54.8583±0.6419 (24)	5[illegible].7292±0.4071 (24)	53.5417±0.7894 (24)

Figures in parenthesis indicate sample size.

Statistical analysis presented in table 6 revealed that the differences between the genetic groups were found to be significant (P$\angle$0.01).

ii) Body Weight at 20 weeks of age.

The means and standard errors of body weight at 20 weeks are presented in table 7.

Among the pure strains considered, IWN strain registered a body weight of 1219.56 ± 12.75 g which was the maximum obtained. On the contrary F strain registered a body weight of 1113.13 ± 9.04 g which was the lowest. IWP strain attained 1152.03 ± 14.88 g.

Among the crosses, IWN x IWP combination attained a body weight of 1238.81 ± 12.13 g which was the highest among all the groups considered. Its reciprocal however registered 1121.64 ± 17.69 g.

IWP x F attained a body weight of 1124.59±20.89 g and its reciprocal also registered a very similar body weight (1124.12 ± 13.43 g).

IWN x F registered a body weight of 1143.65 ± 14.67 g whereas its reciprocal registered only 11[illegible]1.04 ± 12.68 g.

Statistical analysis revealed that the nine genetic

Table 6. Analysis of variance to test the significance of the differences between genetic groups

Source of variation	Degrees of freedom	Mean squares				
		Age at first egg	Body weight at 20 weeks	Body weight at 40 weeks	Egg number	Egg weight
Between genetic groups	8	1343.8787**	161775.7941**	172997.4213**	1898.9518**	45.34**
Error	-	368.4747 (634)	15331.9405 (653)	31508.8861 (581)	398.5970 (583)	11.13 (307)

** Significant at $P < 0.01$.

Figures in parenthesis indicate error degree of freedom.

groups considered differed significantly ($P<0.01$) for this trait as well (Table 6).

iii) <u>Body weight at 40 weeks of age.</u>

The means and standard errors of body weight at 40 weeks of age are presented in table 3. Among the pure strains, IWP strain registered maximum body weight of 16[illegible]8.57 ± 23.99 g and the F strain registered the minimum (1531.71 ± 17.30 g). IWN strain registered a body weight of 1585.51 ± 21.01 g.

Among the crosses, IWN x IWP combination registered the maximum body weight of 1654.84 ± 27.03 g whereas its reciprocal registered only 1536.15 ± 22.[illegible]1 g.

IWP x F combination registered only 1567.79 ± 2[illegible].57 g whereas its reciprocal registered 1605.07 ± [illegible]3.47 g.

IWN x F cross attained a body weight of 1493.[illegible] ± 21.37 g whereas its reciprocal registered 1532.57 ± 18.37 g.

It is also to be pointed out that IWN x F combination registered the least weight among all the groups considered. The statistical analysis of the data revealed that the differences obtained were significant ($P<0.01$) as shown in table 6.

iv) Egg Number.

The means and standard errors of egg production upto 280 days of age are presented in table 4. Among the pure strains, F strain gave an egg yield of 84.23 ± [illegible].11 eggs which was followed by IWP with 73.52 ± 2.02 eggs and then by IWN with 72.07 ± 2.53 eggs.

Among the crosses, F x IWP registered the maximum yield of 80.71 ± 2.08 eggs and its reciprocal gave 80.44 ± 2.09 eggs.

IWN x IWP combination yielded 72.2[illegible] ± 2.9[illegible] eggs in contrast to 66.41 ± 2.95 eggs by its reciprocal. IWN x F gave 73.82 ± 2.91 eggs in contrast to 77.36 ± [illegible].73 eggs by its reciprocals.

The differences observed when tested revealed that they were significant ($P<0.01$) as set out in table 6.

v) Egg Weight.

The means and standard errors of egg weight at 38 weeks of age are presented in table 5. Among the pure strains, IWN gave 55.00 ± 0.61 g followed by F strain 53.54 ± 0.79 g and then by IWP with 53.15 ± 0.53 g.

Among the cross combinations, IWN x IWP registered the maximum egg weight of 55.27 ± 0.76 g whereas its reciprocal gave only a weight of 51 g.

IWP x F combination yielded egg weight of 53.92 $\pm$ 0.77 g whereas its reciprocal registered a weight of 54.86 $\pm$ 0.64 g.

IWN x F combination and its reciprocal revealed an egg weight of 52.43 $\pm$ 0.82 g and 52.73 $\pm$ 0.41 g respectively.

When all the nine groups were considered together the IWN x IWP combination registered the maximum (55.27 $\pm$ 0.76 g) and its reciprocal registered the minimum (51.08 $\pm$ 0.69g).

The statistical analysis on the data revealed that the differences were significant ($P < 0.01$) as set out in table 6.

2. <u>Genetic Analysis</u>.

To find out the nature of the genetic effects controlling the traits, the data were further subjected to analysis following the mathematic model of two-way classification with interaction.

This analysis offered valuable information as to the suitability of the strains as sire and dam lines in as much as the primary concern was in the performance of the particular crosses produced in these traits. The analysis is summarised in table 7.

Table 7. Analysis of variance to test the overall performance of the strains as sire and dam lines and their interactions between them in cross combinations

Source of variation	Degree of freedom	Mean squares				
		Age at first egg	Body weight at 20 weeks	Body weight at 40 weeks	Egg number	Egg weight
Between sire	2	1913.0275**	426377.9**	30665.095	3235.0135**	4[illegible].525*
Between dam	2	2916.0115**	111166.8**	531214.00**	2897.176**	43.560*
Sire x dam	4	176.19445	49400.2*	75984.275*	717.0383	47.6325**
Error	-	358.6167 (634)	15336.2144 (653)	31513.7694 (581)	398.6158 (583)	11.1287 (207)

* Significant at $P \leq 0.05$.

**Significant at $P \leq 0.01$.

Figures in parenthesis indicate error degree of freedom.

i) Age at First Egg.

The three strains differed significantly ($P \angle 0.01$) as sire and dam lines in terms of this trait. However the interaction between the sire and dam lines was not significant.

ii) Body Weight at 20 weeks of age.

The three strains differed significantly ($P \angle 0.01$) as sire and dam lines in this trait as well. The interaction between sire and dam lines was also found to be significant.

iii) Body weight at 40 weeks of age.

The three strains did not differ significantly as sire lines. However the differences observed among them were significant ($P \angle 0.01$) as dam lines. The interaction between sire and dam lines was also found significant ($P \angle 0.05$).

iv) Egg Number.

The three strains involved were found to differ significantly ($P \angle 0.01$) both as sire and dam lines. However, the interaction effects between the sire and dam lines were found to be not significant.

v) Egg Weight.

The three strains differed significantly ($P \angle 0.01$) as sire line for egg weight but the differences observed among them as dam line were found to be significant only at five per cent level. The interactions between sire and dam lines were also found to be significant ($P < 0.01$).

3. The Overall Merits of the Strains as Sire and Dam Lines

The analysis was further proceeded with to assess the fixed effect of the strains as sire and dam lines separately and comparisons were made. The least squares means and the standard errors along with the mean comparisons are tabulated in table 8.

The F strain was found to possess the overall merit as a sire line in as much as this strain yielded cross combinations with low age at maturity, moderate body weight and egg weight and with reasonably good egg yield. The strain IRN yielded crosses which were heaviest and which produced heaviest eggs in the study. The IWP strain yielded crosses which were of moderate value.

When these three strains are compared as to their performance as dam lines, IWP strain performed well as a dam line. The crosses evolved using IWP strain as a dam line matured early (Table 8) had heavier body weight and egg weight and also produced equally good number of eggs. When F strain was used as a female line, the crosses it produced with IWP performed reasonably well. However, the F strain performed

Table 8. Least square means and standard errors of the overall performance of the strains as sire or dam line

Overall effect of strain as sire/dam line	Age at first egg	Body weight at 20 weeks	Body weight at 40 weeks	Egg number	Egg weight
Sire Line					
IWP	184.05±1.3532^{a}	113[illegible].75±8.5331^{b}	1577.5 ±13.2064^{a}	73.46±1.4714^{b}	52.7167±0.4066^{b}
IWN	182.73±1.3209^{a}	1200.67±8.2000^{a}	1577.85±12.9063^{a}	74.37±1.4466^{b}	54.[illegible]293±0.446[illegible]^{a}
F	178.38±1.3209^{b}	1119.43±8.2758^{b}	1556.45±12.104[illegible]^{a}	80.77±1.3637^{a}	53.7097±0.3748^{ab}
Dam Line					
IWP	180.23±1.3209^{b}	1171.65±8.4956^{a}	1629.49±12.7596^{a}	77.15±1.4311^{a}	54.4[illegible]64±0.[illegible]863^{a}
IWN	185.94±1.3209^{a}	1154.08±16.7[illegible]7^{a}	1[illegible]51.41±13.0820^{b}	71.95±1.4537^{b}	52.9375±0.3818^{b}
F	178.99±1.3209^{b}	1127.1[illegible]±8.3987^{b}	133[illegible].9 ±1[illegible].3912^{b}	79.5 ±1.3986^{a}	53.[illegible]917±0.4577^{b}

Means with the same superscripts within the sets do not significantly differ from each other at five per cent level.

better as a sire line in combination with IWP with respect to body weight and egg weight. The egg production in this combination was also better than its reciprocals. Therefore, considering all the traits together, the overall merit of IWP strain as a dam line has to be emphasised.

4. Heterosis

Heterosis was estimated as a contrast between F_1's and the mid parental value as listed in table 9. The mean squares of the estimates of heterosis for 'F' test are presented in table 10. Beneficial effects of heterosis were generated on crossing IWP and F strains for body weight at 40 weeks, egg number and egg weight whose values were 6.29, 1.70 and 1.04 respectively (Table 9). However, none of these reached a level of significance (Table 10). The only significant heterosis observed was for the cross between IWN and F strains for body weights at 20 and 40 weeks of age, and egg weight, whose values were -34.00, -45.71, and -1.70 respectively. However, in these cases the estimates of heterosis were negative.

5. Residual Reciprocal Effects

Residual reciprocal effects are presented in table 9 and the corresponding mean squares in table 10.

Table 9. Estimates of heterosis and residual reciprocal effects

Heterosis/Residual reciprocal effects	Age at first egg	Body weight at 20 weeks	Body weight at 40 weeks	Egg number	Egg weight
Heterosis					
Strain IWP and strain IWN ($h_{IWP \times IWN}$)	1.435	-5.365	-11.545	-0.98	-0.8980
Strain IWP and strain F ($h_{IWP \times F}$)	-1.580	-8.225	6.[illegible]9	1.70	1.04164
Strain IWN and strain F ($h_{IWN \times F}$)	-3.61	-34.000	-45.71	-2.36	-1.6979
Residual Reciprocal Effects					
Strain IWP vs Strain IWN ($r_{IWP \times IWN}$)	8.57	-117.18	-118.69	-10.81	-4.1817
Strain IWP vs strain F ($r_{IWP \times F}$)	2.88	0.47	-37.28	-0.27	-0.9416
Strain IWN vs strain F ($r_{IWN \times F}$)	-1.06	22.61	-39.36	-3.54	-0.3125

$r_{IWN \times IWP} = -r_{IWP \times IWN}$, $r_{F \times IWP} = -r_{IWP \times F}$, $r_{F \times IWN} = -r_{IWN \times F}$

Table 10. Analysis of variance to test the significance of the estimation of heterosis and residual reciprocal effects

Source of variation	Degree of freedom	Mean Squares				
		Age at first egg	Body weight at 20 weeks	Body weight at 40 weeks	Egg number	Egg weight
Heterosis						
Strain IWP and strain IWN ($h_{IWP \times IWN}$)	1	142.4[illegible]07	[illegible]29.4854	8111.6773	59.7366	19.3537
Strain IWP and strain F ($h_{IWP \times F}$)	1	181.6356	4901.0650	2673.4833	199.7788	[illegible]6.0437
Strain IWN and strain F ($h_{IWN \times F}$)	1	[illegible]7.5824	88940.1808*	142162.9[illegible]84*	445.2855	69.1887**
Residual Reciprocal Effects						
Strain IWP vs strain IWN ($r_{IWP \times IWN}$)	1	2462.2804*	488948.9157**	398396.9485**	3464.4560**	[illegible]10.4219**
Strain IWP vs strain F ($r_{IWP \times F}$)	1	290.237[illegible]	7.8[illegible]78	47597.4657	[illegible].4591	10.6393
Strain IWN vs strain F ($r_{IWN \times F}$)	1	39.365[illegible]	19[illegible]88.8390	48260.4779	39[illegible].85[illegible]4	1.1713
Error		368.6167 (634)	15336.2144 (653)	[illegible]1513.7694 (581)	398.6155 (583)	11.1[illegible]87 ([illegible]07)

* Significant at $P \leq 0.05$

** Significant at $P \leq 0.01$

The residual reciprocal effects were found to be significantly higher ($P<0.01$) for the IWN x IWP cross in contrast to its reciprocals for body weights at 20 and 40 weeks of age, egg number and egg weight, whose values are -117.18, -118.69, -10.81 and -4.18 respectively. The IWN x IWP crosses matured at an early age ($P<0.05$) in comparison to its reciprocals and the residual reciprocal effect value was 8.57.

DISCUSSION

DISCUSSION

The data pertaining to age at first egg, body weight at 20 and 40 weeks of age, egg production upto 280 days of age and egg weight at 38 weeks of age of nine genetic groups are presented in table 1 to 5.

1. Age at First Egg

A close examination of the age at first egg revealed that the 'F' strain registered the lowest figure of 176.95 ± 2.16 days among the pure strains. On the other hand, strain IWN attained sexual maturity by 186.93 ± 4.79 days which was the highest. The corresponding figure for IWP strain was 182.49 ± 1.73 days.

Singh and Singh (1979) reported 191.99 ± 3.66 days as the age at sexual maturity for inbred White Leghorn strains and they also reported 175.48 ± 2.34 days as the age at sexual maturity of the incrosses. In this study the average age at sexual maturity of IWN strain is slightly on the higher side.

The difference among the genetic groups for this trait when tested was found to be significant (Table 6).

Hanumaiah <u>et al.</u> (1976) also had reported significant differences between the genetic groups in a crossing experiment using White Leghorn males with White Leghorn and Rhode Island Red pullets.

Among the cross combinations, F x IWP combination attained sexual maturity by 176.69 ± 2.30 days which was the lowest among all the groups studied. The reciprocals registered 179.58 ± 1.78 days which was the second lowest. The IWN x IWP combination attained sexual maturity by 181.31 ± 2.15 days which also can be considered as a reasonably satisfactory age at first egg. However its reciprocals attained sexual maturity by 190.08 ± 2.[illegible]4 days which has to be considered as on the higher side. The residual reciprocal effects were found to be significantly high ($P < 0.05$) for IWN x IWP cross in contrast to its reciprocals for this trait. Singh <u>et al.</u> (1980a) also had reported reciprocal effects for this trait making use of the strains IWN and IWH, even though the difference between the crosses did not reach a significant level.

The F x IWN combination and its reciprocal registered 181.51 ± 2.06 and 180.45 ± 2.[illegible]1 days respectively as the age at first egg, which can be considered as reasonably satisfactory. Thus, both F x IWP and its reciprocals exhibited very satisfactory level of performance for this trait. In general, it was observed that barring IWP x IWN, the crosses registered values close to mid parental values. Therefore, it is reasonable to infer that selection for this trait can be continued in the pure strains for a few more generations as opined by Cole and Hutt (1973) that the improvement [illegible] the performance of the parentals will not diminish heterosis.

3. Body Weight at [illegible] Weeks of Age

A perusal of the data on body weight at [illegible] weeks of age revealed that the pure strain [illegible] had the maximum body weight of 1[illegible]19.56 ± 1[illegible].7[illegible] g and the [illegible] strain had the minimum body weight of 111[illegible].13 ± 9.[illegible]4 g. Strain [illegible] attained a body weight of 11[illegible].03 ± 14.3[illegible] g at [illegible] weeks of age.

The difference among the genetic groups was found to be highly significant. Hanumaiah et al. (1976) also found and reported significant differences in body weight between genetic groups in a crossing experiment. A higher body weight at [illegible] weeks of age for [illegible] strain was not reflected in its age at sexual maturity. On the contrary the [illegible] strain which registered the least body weight at [illegible] weeks of age, attained sexual maturity earlier than other pure strains. This can probably be due to the longer period of time for which this strain would have undergone selection for egg number alone.

Among the crosses, the IWN x IWP combination attained body weight of 1238.82 ± 12.13 g which was the highest among all the groups. However its reciprocal registered only 1121.64 ± 17.69 g. Hale and Clayton (1965) also observed consistent reciprocal differences between crossbreds in pullet weight at 18 weeks of age in a six year study of diallel crosses. Yoos (1966) also reported, in a diallel mating of 17 strains of chicken, that reciprocal effects were very important in body weight of female egg type chickens. Jain et al. (1981) observed, from a diallel mating making use of four White Leghorn strains, that the variance due to reciprocal effects was significant for body weight.

The body weight registered by the IWP x F and its reciprocals were around 1124 g which was approaching the mid parent value. The IWN x F cross combination and its reciprocals registered body weight of 1143.65 ± 14.67 g and 11[illegible]1.04 ± 1[illegible].68 g respectively, both of which were higher than the value registered by F strain (1113.13 ± 9.04 g).

3. Body Weight at 40 Weeks of Age

Among the pure strains IWP registered the maximum body weight of 1628.57 ± 23.99 g and F strain registered the minimum of 1531.70 ± 17.30 g. IWN strain registered body weight of 1585.51 ± 21.01 g. When all the nine genetic groups were considered together it was observed that the combination IWN x IWP registered maximum (1654.84 ± 27.03 g) whereas its reciprocal gave only 1536.15 ± 22.31 g.

The body weight at 40 weeks of age may be indicative of the health status of the bird apart from its relationship with egg weight. The differences between the genetic groups were found to be highly significant (Table 6).

Strain F was the lightest among the pure strains and it also showed a similar trend at 20 weeks of age. However, the F x IWP combination registered body weight of 1605.07 ± 23.48 g which can be considered as satisfactory. This combination exceeded mid parental value in this trait. Hutt and Cole (1952) reported that the hybrids, making use of two improved non-inbred strains of White Leghorn, weighed more in comparison to their purebred half sisters in two successive years. King and Bruckner (1952) also observed heterosis in body weight. The body weight of IWP x F combination was only 1567.79 ± 22.57 g which indicated that it would be desirable to use F strain as sire line. Nordskog (1956) obtained statistically significant differences between the reciprocal crosses for body weight of pullets. Yoes (1966) also opined based on a diallel mating of 17 strains of five breeds of chicken that reciprocal effects were very important in determining body weight of female egg type chicken. Batra *et al.* (1974) observed that specific combining ability was largely responsible for body weight. Das *et al.* (1978) also reported reciprocal effects for body weight at 30 and 40 weeks of age in a diallel mating involving four White Leghorn strains.

Among the crosses IWN x IWP and F x IWP combinations showed satisfactory levels of performance in respect to this trait. Further refinement in this trait is very likely to be accomplished through purebred selection schemes in as much as body weight is a trait having moderate heritability.

4. Egg Number

Among the pure strains, F strain registered maximum yield of 84.23 ± 2.11 eggs which was followed by IWP strain with 73.52 ± 2.02 eggs and by IWN strain with 72.07 ± 2.53 eggs.

Among the crosses, F x IWP gave 80.71± 2.08 eggs which was the maximum and it was more than the mid parental value. Its reciprocal yielded 80.44 ± 2.09 eggs which was also more than the mid parental value. F x IWN combination yielded 77.36 ± 3.73 eggs which was approaching the mid parental value of 78.46 eggs. However, its reciprocal yielded only 73.8? ± ?.91 eggs. A comparison of IWN x IWP and its reciprocals revealed that the former was a better combination, approaching the mid parental value of 7?.79 eggs. The differences among the genetic groups were found to be significant ($P < 0.01$).

Hutt and Cole (1951 and 1952) reported that the inter-strain hybrids had exhibited consistent influence of heterosis in raising egg production. Nordskog and Ghostley (1954) observed that the strain crosses and crossbreds exceeded the purebreds in total egg production. Goto and Nordskog (1959) also had reported statistically significant sire line and dam line differences from inbred line diallel crosses of White Leghorn for hen-housed egg production. They also observed that the general combining ability was more important than specific combining ability for this trait. Kuit (1965); Wearden et al. (1965); Singh and Singh (1971); Sergeev and Sergeeva (1973); Batra et al. (1974); Eftimov et al. (1974); Orozco and Campo (1975); Reddy and Mohapatra (1975); Hanumaiah et al. (1976); Jain and Mohanty (1979); Singh and Singh (1979) and Jain et al. (1981) reported beneficial effects of heterosis in improving this trait in White Leghorn. However, in the present study, the combination F x IWP yielded the maximum beneficial effects in improving this trait. In the light of the observation of Cole and Hutt (197?), it is suggested that further refinement in both F and IWP strains be made since heterosis will not diminish even when the pure strains are markedly improved.

5. Egg Weight

The data pertaining to egg weight at 38 weeks of age presented in table 5 revealed that IWN strain had maximum egg weight of 55 $\pm$ 0.61 g. Since egg weight is negatively correlated with egg number, IWN yielded minimum number of eggs among the pure strains. The egg weight of IWP (53.15 $\pm$ 0.53 g) and F (53.54 $\pm$ 0.79 g) strains were very much comparable.

Among the cross combinations, IWN x IWP registered maximum egg weight of 55.27 $\pm$ 0.76 g whereas its reciprocal yielded 51.08 $\pm$ 0.69 g. F x IWP combination registered 54.86 $\pm$ 0.64 g which was the second highest among the crosses.

Statistical analysis of the data indicated that the differences observed among the different genetic groups were significant ($P<0.01$) as shown in table 6. The three strains also differed significantly as sire line ($P<0.05$) as well as dam line ($P<0.05$). Beneficial effects of heterosis for this trait were observed only in combinations of IWP and F strains. However, the heterosis did not reach a level of significance.

Brunson and Godfrey (1951) observed that cross-breeding did not result in consistent improvement in egg weight. Hutt and Cole (1952), on the contrary, observed from the reciprocal diallel crossing of two improved non-inbred strains of White Leghorn that the hybrids laid bigger eggs in comparison to the purebred half sisters. The absence of heterosis for this trait was reported by King and Bruckner (1952), Nordskog and Ghostley (1954); Yoes (1966) and Sergeev and Sergeeva (1973). However, in the present study, the beneficial effects observed in this trait might be due to sire line and dam line differences. IMN x IUP and F x IUP combinations performed much better in comparison to other crosses. Goto and Nordskog (1959) also reported statistically significant sire line and dam line differences in egg weight from a diallel crossing. They also reported that general combining ability was more important than specific combining ability for egg weight. Hale and Clayton (1965) also had observed consistent reciprocal differences between crosses for egg weight in a six year study of diallel crossing. Shkredov _et al._ (1973) also had opined that heterosis was not important for egg weight. Batra _et al._ (1974) had reported heavier eggs in strain crosses than the pure strains in a 5 x 5 diallel crossing experiment of White Leghorn strains, as was observed in a few cross combinations in this study. They also indicated that general combining ability was more important for egg weight.

An overall consideration of all the traits in the nine genetic groups studied would indicate the general genetic make up. When the results are summed up, it was observed that F strain performed reasonably well both as a pure strain as well as in cross combinations with IWP strain. However, the heterosis generated in crossing these two strains did not reach a level of significance to merit a crossbred selection scheme in the place of the present purebred selection scheme. Therefore, it is suggested that pure-bred selection scheme may be continued in these strains for improvement of the important economic traits.

The results of the present study also indicated that IWP strain when used as a dam line produced better crosses in terms of the production traits considered. F x IWP cross gave reasonably satisfactory performance with respect to most of the traits considered and this combination may be a prospective commercial cross for table egg production. IWN x IWP combination can also be considered as a combination with good potential. Efforts to bring about further improvement in these traits in these pure strains by intra-population selection should be continued since heterosis of economic importance is most likely to occur in crosses between populations already selected in the desired direction as opined by Bowman (1959) and Cole and Hutt (1973).

SUMMARY

SUMMARY

A 3 x 3 diallel crossing experiment was conducted at the All India Co-ordinated Research Project on Poultry for Eggs, Trichur centre using IWP, IWN and F strains of White Leghorn and generated nine genetic groups consisting of three purebreds and six crossbreds including reciprocals. Age at first egg, body weight at 20 and 40 weeks of age, egg number upto 280 days of age and egg weight at 39 weeks of age were recorded for all the genetic groups.

Among the purebreds, F strain performed best with the birds attaining maturity earliest (176.95 ± 2.16 days), light in their body weight at 20 and 40 weeks of age (1113.13 ± 9.04 g and 1531.71 ± 17.30 g respectively), highest in egg production (84.23 ± 2.11 eggs) and with moderate egg size (53.54 ± 0.79 g). IWN strain was the heaviest purebred with a body weight of 1219.56 ± 12.75 g at 20 weeks of age. They were late maturers (186.23 ± 4.78 days) yielding comparatively less number of eggs (72.07 ± 2.53 eggs) but the egg size was the largest (55.00 ± 0.61 g). IWP strain was mostly intermediate in all the production traits considered except for body weight at 40 weeks of age which was found to be 1628.57 ± 23.99 g, the heaviest among the purebreds.

IWP x IWN, IWN x IWP and F x IWP crosses exceeded their parental levels in age at maturity, body weight at the two ages and egg weight respectively. Body weight at 40 weeks of age in IWN x F cross was found to be considerably less than the two parental strains. The production levels of other crosses were mostly either midway between or nearer to one of their parental strains.

Phenotypic analysis showed highly significant differences between genetic groups ($P < 0.01$) in all cases reflecting the presence of genetic viability. In genetic analysis, the three strains differed significantly ($P < 0.01$) in all the traits as sire and dam lines except for egg weight where the significance was only at five per cent level. The interaction between sire and dam lines was significant ($P < 0.05$) for the body weight 20 and 40 weeks of age and highly significant ($P < 0.01$) for egg weight, reflecting the influence of specific combining ability and/or residual reciprocal effect.

When the overall merit of the strains as sire line is considered, F strain was found to be best in cross combinations with low age at maturity, moderate body weight and egg weight and reasonably good egg yield. IWN strain yielded heaviest crossbreds producing heaviest eggs, while the IWP strain produced crossbreds of moderate value.

IWP strain appeared to perform well as a dam line and crosses evolved using IWP strain as a dam line were heavy in body and egg weight, matured early and also produced reasonably good number of eggs. F x IWP cross performed reasonably well in respect of most of the traits considered. IWN x IWP combination was also observed to be another promising strain-cross.

A positive heterosis was observed when F and IWP strains were crossed, though the heterosis thus generated failed to reach a significant level. F x IWP cross gave reasonably satisfactory performance with respect to most of the traits considered and this combination may be prospective commercial cross for table egg production. Two combinations, viz. F x IWP and IWN x IWP may be exposed for extensive field testing. However, further refinement in the economic traits in these strains by purebred selection scheme is warranted.

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GENETIC EFFECTS INFLUENCING EGGER TRAITS FROM DIALLEL MATING SYSTEM

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ABSTRACT OF A THESIS

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ABSTRACT

A 3 x 3 diallel cross was made using IWP, IWN and F strains of White Leghorn at the All India Co-ordinated Research Project on Poultry for Eggs, Trichur centre. Age at first egg in days, body weight at 20 and 40 weeks of age in grammes, egg number upto 280 days of age and egg weight (g) at 38 weeks of age were recorded for all the nine genetic groups.

Strain F was found to be superior in performance among the purebreds in terms of the traits considered in the study.

The overall merit of F strain, as sire line, was found to be good, yielding birds in cross combinations with low age at maturity, moderate body weight and egg weight and satisfactory egg yield.

IWP strain appeared to perform well as a dam line and crosses produced using IWP strain as a dam line were heavy in body weight and egg weight matured early and also produced equally good number of eggs. F strain when used as a female line might be more economical as they produced lighter hybrids capable of producing good number of eggs and maturing early. However, the impact on egg weight has to be critically assessed.

Beneficial heterosis of significance was not generated upon crossing. However, a positive heterosis was obtained when F and ILP strains were crossed but it did not reach a level of significance. ILN x ILP was also found to be a cross with good potential and as such both F x ILP and ILN x ILP crosses may be exposed for extensive field testing while efforts to improve the production potential in these strains may be continued by appropriate intra-population selection method.