PRODUCTION PERFORMANCE OF RECIPROCAL CROSSES OF WHITE LEGHORN STRAINS UNDER DEEP LITTER SYSTEM

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DECLARATION

I hereby declare that the thesis entitled **"PRODUCTION PERFORMANCE OF RECIPROCAL CROSSES OF WHITE LEGHORN STRAINS UNDER DEEP LITTER SYSTEM"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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CERTIFICATE

Certified that the thesis entitled **"PRODUCTION PERFORMANCE OF RECIPROCAL CROSSES OF WHITE LEGHORN STRAINS UNDER DEEP LITTER SYSTEM"** is a record of research work done independently by **Shri. K. Giriraj**, 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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We, the undersigned members of the Advisory Committee of **Shri. K. Giriraj,** a candidate for the degree of Master of Veterinary Science in Poultry Science, agree that the thesis entitled **"PRODUCTION PERFORMANCE OF RECIPROCAL CROSSES OF WHITE LEGHORN STRAINS UNDER DEEP LITTER SYSTEM"** may be submitted by Shri. K. Giriraj, in partial fulfilment of the requirement for the degree.

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K. GIRIRAJ

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Introduction

1. INTRODUCTION

During the past four decades the entire scenario of poultry farming in the country has changed. It is now recognized as an organized and scientifically based industry and is a potential tool to fight poverty and malnutrition. The total egg production in the country has increased from 5,340 million eggs in 1971, to about 30,629 million eggs in the year 2000. Presently, India stood fifth in world egg production. The per capita availability of eggs per annum (34 eggs) is well below the recommendation of Indian Council for Medical Research (Anon, 2003-04). In order to bridge this gap by increasing egg production, emphasis should be bestowed on genetic improvement of flock, feed management and biosecurity measures.

The strain crosses by virtue of their superiority for economic traits over their parents are of the choice for commercial exploitation. The superiority in economic traits like egg production, viability and age at sexual maturity in strain crosses is due to heterosis or hybrid vigour. Strain crosses differ among themselves in their performance due to difference in nicking ability of the strains. The magnitude of heterosis in strain crosses depends on the difference in gene frequency between the parental lines and the interaction of genes in the progeny. Therefore, variable amount of heterosis may be exhibited by various crosses depending upon the specificity and divergence among the lines involved and the environment to which the animals are subjected (Orozco and Campo, 1975). Therefore, strains should be evaluated periodically in cross performance for their better exploitation in commercial breeding programmes.

The All India Co-ordinated Research Project on Poultry at Mannuthy Centre is engaged in the pureline breeding with IWN and IWP White Leghorn strains since 1976. Strict selection procedures were employed upto 20 generations and at present evaluation of 21st generation started at this centre. In

1990 a strain cross of N x P was released for commercial exploitation called as ILM-90 and christened as Athulya, which received better appreciation among Kerala farmers. The technical programme is mainly concentrated on pureline breeding and the cross performance was studied before 1998 only under cage system of rearing. As the pureline breeding is the mandate to this centre, the cross performance of N x P and P x N strain crosses needs to be evaluated to assess the efficiency of selection.

Encouraging results were obtained with this strain cross consequently for last two years (2001 and 2002) under deep litter system in the recent Random Sample Layer Test conducted by Government of India at Hessarghatta.

Studies to assess the performance of the reciprocal crosses of IWN and IWP under deep litter system of management have not been attempted in our climatic condition. In Kerala the poultry farmers are marginal class capable of rearing layers under deep litter system. All these factors paved the way of evaluating the cross performance of both these White Leghorn strains.

So the present study was undertaken to evaluate and compare the layer production traits of reciprocal crosses of IWN and IWP strains under deep litter system of rearing.

Review of Literature

2. REVIEW OF LITERATURE

2.1 BODY WEIGHT

Chaudhuri *et al.* (1976) observed that White Leghorn strain L33 under cage system was heavier and weighed 1050 and 1784 g at 20 and 40 weeks of age, respectively than other White Leghorn strains namely L55, L77 and L99.

Benjamin and Choudary (1977) studied two-way crosses and their reciprocals using a modified diallel cross from A, B and C strains of White Leghorn and reported that in deep litter system the BC combination had highest body weight as 1799 g and CC the lowest as 1457 g at 35 weeks of age and also found that the crosses having B and A as male parents were significantly heavier than their reciprocals.

Nair *et al.* (1979) recorded that the body weight at 35 weeks of age in the four two-way crosses namely 1x2, 2x1, 1x3 and 3x1 maintained in deep litter system were 1633, 1631, 1605 and 1063 g, respectively and found that 1x2 combination registered highest body weight. At 18 weeks of age it was 1186, 1163, 1191 and 1157 g, respectively.

Reddy *et al.* (1980) found the body weight of L35, L37, L39, L53, L57, L59, L73, L75, L79, L93, L95 and L97 strains of White Leghorn housed in cages were 1160, 1120, 1100, 1180, 1070, 1060, 1100, 1080, 1040, 1110, 1060 and 1030 g, respectively at 20 weeks of age. At 40 weeks of age, the body weights were 1770, 1750, 1780, 1780, 1660, 1690, 1700, 1720, 1680, 1780, 1720 and 1650 g, respectively.

Thiyagasundram *et al.* (1982a) reported that the body weight at 20 weeks of age in L53, L57, L59, L93, L95 and L97 strains of White Leghorn when grown under cage system were 1196, 1236, 1105, 1185, 1148 and 1168 g, respectively. At 40 weeks of age, it was 1521, 1519, 1461, 1541, 1562 and 1626 g, respectively.

Fairfull *et al.* (1983) conducted an experiment in six selected strains of White Leghorn (1,3,2,4,9 and 8), thirty strain crosses, best cross (1 x 8), two commercial stocks (A and B) and two control strains (5 and 7) of White Leghorn birds and observed a mean body weight of 1370, 1430, 1460, 1480, 1330, and 1280 g in six selected strains, thirty strain crosses, best strain cross, two commercial stocks and two control strains, respectively at 136 days of age in single bird cage.

Abplanalp *et al.* (1984) found that average body weight of two line crosses was 1349 g at 20 weeks of age when housed under cage system.

Johari *et al.* (1984) studied the White Leghorn strain cross pullets of six genetic groups (L53, L57, L59, L93, L95 and L97) and reported that the mean body weight at 20 weeks of age in strain crosses were 1170.59 and 1102.44 g in cage and floor housing system, respectively. At 40 weeks of age it was 1533.79 and 1607.92 g, respectively.

Dey *et al.* (1987) recorded the body weight of strain and breed cross involving White Leghorn strain L55 as male parent, White Leghorn strain L33 and Rhode Island Red as 944.03 ± 21.32 and 1087.83 ± 13.14 g, respectively at 20 weeks of age, whereas their body weights at 40 weeks of age were 1365.00 ± 24.86 and 1499.33 ± 16.949 g, respectively.

Johari *et al.* (1988) found that average body weight at 20 weeks of age in selected and control line White Leghorns maintained in cages were 952.24 and 922.89 g, respectively. At 40 weeks of age it was 1529.73 and 1560.88 g, respectively.

Goswami and Shukla (1989) utilized the six White Leghorn strain crosses (III, IV, V, VI, VII and VIII) and reported that the pooled mean body weight at 20 weeks of age in strain crosses, reared in cage and deep litter were 1287.1 and 1339.5 g, respectively.

Kumararaj *et al.* (1990) recorded the average body weight at 20 weeks of age in Meyer x Forsgate strains of White Leghorn and their reciprocal cross maintained in breeding pen were 1305 ± 9.7 and 1264 ± 9.54 g, respectively. At 40 weeks of age it was 1475 ± 11.18 and 1478 ± 11.29 g, respectively.

Mahesh Dutt *et al.* (1990) studied the crossbreds obtained from three strains of White Leghorn (G, L and M) and observed that body weight at 20 and 40 weeks of age grown under cage system were significant among strain crosses, except at day old age.

Yadav *et al.* (1991) found that mean body weight of TV and VT White Leghorn strain crosses housed in cages were 1093.10 ± 5.15 and 1196.04 ± 8.00 g, respectively at 20 weeks of age. TV cross in comparison to its reciprocal showed significantly lower body weight.

Sharma *et al.* (1992) recorded the body weight of reciprocal crosses viz., RIW x RIR, IWH x RIR and IWH x RIW as 1399.67 ± 16.96, 1331.67 ± 19.28 and 1288.70 ± 35.40 g, respectively at 20 weeks of age. At 40 weeks of age the body weights were 1914.36 ± 27.85, 1627.58 ± 26.56 and 1541.37 ± 41.50 g, respectively under cage system of rearing.

Singh *et al.* (1992) observed the body weight of reciprocal crosses of two White Leghorn strains (PL12 and PL21) as 1140 ± 5.2 and 1145 ± 5.9 g, respectively at 20 weeks of age. At 40 weeks of age it was 1430 ± 5.6 and 1424 ± 6.1 g, respectively when reared under cage system.

Srivastava *et al.* (1993) recorded the body weight of IWN and IWP strains under cage system at 20 weeks of age as 1126 and 1232 g, respectively in S4 generation. At 40 weeks of age it was 1611 and 1692 g, respectively.

Chaubal *et al.* (1994) stated that in cage system the DK birds had significantly ($P<0.05$) lower body weight at eight, 20 and 40 weeks of age than DD birds in both S2 and S3 generations.

Khatkar *et al.* (1995) found that average body weight at 20 weeks of age in PL1 and PL2 White Leghorn strains as 1012 ± 1.82 and 1074 ± 1.85 g, respectively. At 40 weeks of age, it was 1480 ± 2.10 and 1590 ± 1.92 g, respectively.

Chaudhary *et al.* (1997) observed the body weight of pure and crosses of White Leghorns as 1105 ± 2.10 and 1140 ± 4.34 g, respectively at 20 weeks of age. At 40 weeks of age, it was 1445± 3.92 and 1450 ± 5.70 g, respectively.

Laly John *et al.* (2000) found that in cage system the average body weight at 20 weeks of age in IWN and IWP strains as 1248.50 ± 6.00 and 1326.80 ± 4.00 g, respectively in S15 generation. The average phenotypic response per generation was 5.20 g in IWN and 6.54 g in IWP strain, respectively.

Prabhakaran *et al.* (2001) reported that the body weights for IWN and IWP strains and control population of White Leghorn maintained in cages were 1.330 ± 0.01, 1.421 ± 0.02 and 1.229 ± 0.01 kg at 20 weeks of age and 1.539± 0.02, 1.546 ± 0.02 and 1.445 ± 0.02 kg at 40 weeks of age, respectively.

Brah *et al.* (2002) found that in deep litter system the average body weight of PL12 and PL21 strain crosses were 1023 ± 8.34 and 1020 ± 7.96 g, respectively at 20 weeks of age. At 40 weeks of age it was 1428 ± 13.4 and 1410 ± 13.3 g, respectively.

Singh *et al.* (2002) reported that the differences between the two reciprocal crosses of White Leghorn (PL21 and PL12) for 20 and 40 week body weights were significant in two of the three generations. However, the direction of the difference between the two reciprocal genes was consistent with cross PL21 being heavier than cross PL12 in amounts varying between 32 and 64 g.

2.2 AGE AT SEXUAL MATURITY

Chaudhuri *et al.* (1976) observed that under cage system the age at first egg averaged 201, 192, 192 and 191 days in L33, L55, L77 and L99 White Leghorn strains, respectively.

Benjamin and Choudary (1977) reported that in deep litter system the age at first egg in the AC, AB, BC, BA, CB, CA and CC crosses were 189.6, 185.8, 185.1, 187.6, 190.4, 190.9 and 197.9 days, respectively and found that crosses out of B males than B females and also the crosses with B strains as male parents laid their first egg earlier to those having A and C strains as male parents.

Reddy *et al.* (1980) recorded mean age at sexual maturity in L35, L37, L39, L53, L57, L59, L73, L75, L79, L93, L95 and L97 White Leghorn strain crosses maintained in cages were 169.0, 177.8, 177.7, 174.3, 178.4, 175.4, 173.4, 170.7, 175.2, 178.6, 177.9 and 179.8 days, respectively.

Singh *et al.* (1980) observed that age at first egg in IWH x IWI and their reciprocal cross IWI x IWH under cage system was 163.7 and 158.75 days, respectively. But the difference between the two crosses was not significant.

Thiyagasundaram *et al.* (1982a) observed that in cage system the overall mean age at first egg were 158.93, 157.08, 161.39, 160.67, 158.63 and 160.86 days in L53, L57, L59, L93, L95 and L97 strain crosses, respectively.

Fairfull *et al.* (1983) conducted an experiment in six selected strains of White Leghorn (1,3,2,4,9 and 8), thirty strain crosses, best cross (1 x 8), two commercial stocks (A and B) and two control strains (5 and 7) of White Leghorn birds and found that the average age at first egg were 150, 146, 142, 146, 148 and 167 days in six selected strains, thirty strain crosses, best strain cross, two commercial stocks and two control strains, respectively in single bird cages. The age at 50 per cent production were 153, 149, 142, 151, 154 and 173 days, respectively.

Johari *et al.* (1984) carried out an experiment in six White Leghorn strain crosses (L53, L57, L59, L93, L95 and L97) and reported the age at 10 per cent production in strain crosses were 144.64 and 152 days, respectively in cage and floor housing systems. The age at 50 per cent production was 162.94 and 172.04 days, respectively.

Verma *et al.* (1985) studied a 4 X 4 diallel crossing involving four strains of White Leghorn (L33, L55, L77 and L99) and recorded the mean age at 50 per cent production in strain crosses and pure strains were 150.69 and 155.54 days, respectively when grown under cage system.

Dey *et al.* (1987) found that the age at sexual maturity of strain and breed crosses involving L55 White Leghorn strain as male parent, L33 White Leghorn strain and Rhode Island Red (RIR) were 158.97 ± 1.28 and 157.13 ± 0.75 days, respectively.

Johari *et al.* (1988) found that in cage system mean age at first egg as 161.53 and 184.34 days in selected line and control line White Leghorns, respectively.

Kumararaj *et al.* (1990) reported that mean age at first egg in Meyer x Forsgate strains of White Leghorn and their reciprocal crosses were 145 and 147 days, respectively when reared in breeding pen.

Mahesh Dutt *et al.* (1990) reported that under cage system the MG and ML White Leghorn crosses showed significantly lower age at sexual maturity.

Yadav *et al.* (1991) observed that in cage system the average age at sexual maturity in TV and VT strain crosses were 153.09 and 157.08 days, respectively. TV cross, in comparison to its reciprocal matured significantly earlier.

Sharma *et al.* (1992) found the age at sexual maturity of reciprocal crosses RIW x RIR, IWH x RIR and IWH x RIW as 154.98 ± 1.29, 141.27 ± 1.02 and 141.27 ± 1.27 days, respectively when reared under cage system.

Srivastava *et al.* (1993) observed the mean age at sexual maturity in IWN and IWP strains as 166.6 and 167.2 days, respectively at S4 generation under cage system of rearing.

Chaubal *et al.* (1994) stated that age at first egg in DD, KK, DK and KD White Leghorn strains maintained in cages were 147.12, 160.32, 145.87 and 159.64 days, respectively at S3 generation. At S4 generation it was 149.74, 154.49, 151.89 and 150.52 days, respectively.

Khatkar *et al.* (1995) reported the age at first egg as 166 ± 0.21 and 163 ± 0.19 days in PL1 and PL2 White Leghorn strains, respectively.

Chaudhary *et al.* (1997) observed mean age at first egg in pure strain and crosses as 153 ± 0.24 and 151 ± 0.55 days, respectively.

Laly John *et al.* (2000) found that in cage system the average age at first egg in IWN and IWP strains was 167.28 ± 0.64 and 159.22 ± 0.39 days, respectively. The average phenotypic response per generation was –0.57 ± 0.40 days in IWN and –0.73 ± 0.41 days in IWP and were found to be statistically non-significant.

Prabhakaran *et al.* (2001) reported the age at sexual maturity of IWN and IWP strains and control population of White Leghorn as 149.53 ± 0.89, 136.41 ± 0.89 and 153.85 ± 0.90 days, respectively whereas for 50 per cent production, the values were 153, 143 and 162 days, respectively when housed under cage system.

Singh *et al.* (2002) stated that in cages the differences between reciprocal crosses for sexual maturity were not significant. Numerically, however, PL21 matured earlier.

2.3 EGG PRODUCTION

Chaudhuri *et al.* (1976) observed that under cage system the egg production of L33, L55, L77 and L99 were 54.33, 58.64, 57.68 and 62.19 eggs, respectively upto 280 days of age.

Benjamin and Choudary (1977) reported the egg number upto 280 days of age in the AC, AB, BC, BA, CB, CA and CC strain crosses maintained in deep litter system was 68.64, 70.42, 69.26, 73.06, 61.36, 63.09 and 67.10, respectively and found that hen-housed production was significantly better for AB and BA combinations as compared to all others.

Nair *et al.* (1979) recorded the hen-housed number of 239.06, 237.82, 221.62 and 226.84 in 1x2, 2x1, 1x3 and 3x1 strain crosses of White Leghorn, respectively for a period of 500 days under deep litter system of rearing. The hen-day numbers were 250.40, 245.21, 231.02 and 238.24, respectively.

Reddy *et al.* (1980) reported an average hen-housed production of L35, L37, L39, L53, L57, L59, L73, L75, L79, L93, L95 and L97 strains of White Leghorn housed in cages were 69.4, 67.0, 71.4, 73.9, 65.3, 70.9, 73.7, 76.6, 66.6,72.8, 65.6 and 67.2 eggs, respectively upto 40 weeks of age.

Singh *et al.* (1980) observed that egg production upto 40 weeks of age in IWH x IWI and their reciprocal cross IWI x IWH were 84.2 ± 0.66 and 87.05 eggs, respectively in cage system of rearing. The egg production till 40 weeks of age had significantly negative correlation with age at first lay.

Singh *et al.* (1981) reported that in cage system the average egg production in IWI x IWH, IWH x IWI, IWI and IWH were 87.08, 84.23, 86.78 and 83.32 eggs, respectively upto 40 weeks of age and found that birds of IWI x IWH produced more eggs than their reciprocal cross and pure bred birds.

Thiyagasundaram *et al.* (1982b) observed that the egg number upto 15 months of age in L53, L57, L59, L93, L95 and L97 strain crosses housed in cages were 185.56, 202.45, 193.85, 191.98, 188.44 and 189.72 eggs, respectively. At 40 weeks of age the egg number were 90.56, 96.73, 91.31, 92.69, 94.27 and 90.08 eggs, respectively.

Fairfull *et al.* (1983) conducted an experiment in six selected strains of White Leghorn (1,3,2,4,9 and 8), thirty strain crosses, best cross (1 x 8), two commercial stocks (A and B) and two control strains (5 and 7) of White Leghorn and recorded that hen-housed egg production averaged 107, 113, 122, 114, 103 and 84 in the six selected strains, thirty strain crosses, best strain cross, two commercial stocks and two control strains, respectively upto 272 days of age in single bird cages.

Abplanalp *et al.* (1984) observed that egg number for the entire four week term in two line crosses maintained in cages was 26.3 ± 0.2 eggs.

Johari *et al.* (1984) conducted an experiment in six White Leghorn strain crosses (L53, L57, L59, L93, L95 and L97) and reported that hen-housed egg number upto 280 days of age in strain crosses were 88.73 and 77.32 eggs, respectively in cage and floor housing system.

Verma *et al.* (1984) found that under cage system the heritability estimates for both part and annual egg production were low in pure strains than

that of strain crosses. However the heritability of egg production upto 285 days of age was high in strain crosses.

Giri and Patro (1985) reported that average hen-housed production upto 280 days of age in MxM, TxT and VxV strains were 59.64, 42.69 and 41.73 eggs, respectively. The average hen-day production was 65.22, 49.99 and 49.10 eggs, respectively. The average hen-housed production in MxT, TxM, MxV, VxM, VxT and TxV strain crosses were 45.34, 50.16, 47.94, 45.47, 42.69 and 43.83 eggs, respectively. The hen-day production was 48.26, 63.00, 50.79, 48.67, 41.18 and 47.24 eggs, respectively.

Verma *et al.* (1985) conducted a 4 X 4 diallel crossing involving four strains of White Leghorn (L33, L55, L77 and L99) and recorded the weighted means for egg production upto 285 days in strain cross and pure strains as 132.49 and 131.60 eggs, respectively under cage system.

Dey *et al.* (1987) reported the egg number upto 280 days of age as 78.79 and 84.13 in L55 x L33 strain crosses and L55 x Rhode Island Red crosses, respectively. The annual egg number in the cross was found to have significant and negative correlation with age at sexual maturity.

Johari *et al.* (1988) found that egg number upto 280 days of age in selected and control line of White Leghorns housed in cages were 86.35 ± 0.74 and 84.88 ± 0.92 eggs, respectively.

Goswami and Shukla (1989) utilized the six White Leghorn strain crosses (III, IV, V, VI, VII and VIII) and recorded that the pooled egg number upto 40 weeks of age in White Leghorn strain crosses reared in cage and deep litter were 94.58 ± 1.41 and 88.21 ± 1.70 eggs, respectively.

Anon (1990) reported that the hen-housed egg production potential of N x P strain cross was 280 eggs.

Mahesh Dutt *et al.* (1990) observed that in cage system the MG and ML White Leghorn crosses showed higher egg production upto 280 days, but were statistically different with LM and GL crosses.

Kumararaj *et al*. (1991) recorded that egg number upto 40 weeks of age in Meyer x Forsgate and Forsgate x Meyer crosses as 99.461 ± 1.2 and 104.6642 ± 0.82 eggs, respectively.

Yadav *et al.* (1991) reported that first 100-day egg production in TV and VT crosses maintained in cages were 71.61 and 69.65 eggs, respectively.

Sharma *et al.* (1992) observed that in cage system the egg number upto 280 days of age in reciprocal crosses RIW x RIR, IWH x RIR and IWH x RIW was 77.98 ± 2.54, 94.86 ± 3.32 and 94.87 ± 4.24 eggs, respectively.

Singh *et al.* (1992) reported that under cage system the egg number upto 40 weeks of age in reciprocal crosses of two White Leghorn strains (PL12 and PL21) was 100.7 ± 0.7 and 97.7 ± 1.0 eggs, respectively.

Chaubal *et al.* (1994) stated that in cage system the egg production (EN40) significantly improved in all genetic groups (DD, KK, DK and KD) in S3 generation. The egg production of DK (104.75) was significantly ($P<0.05$) higher than that of DD (101.58) in S3 generation.

Brah *et al.* (1995) reported that egg number upto 40 weeks of age in PL12 and PL21 crosses was 83.1 ± 1.35 and 87.2 ± 1.40 eggs, respectively under deep litter system of rearing.

Kharadi *et al.* (1995) studied seven strain crosses of White Leghorn (A, B, C, E, F, L and H) and reported that the average hen-housed (HH) production of strain crosses in cage and deep litter was 209.7 ± 3.5 and 216.7 ± 5.5 eggs, respectively upto 68 weeks of age. The hen-day (HD) production was 226.9 ± 3.1 and 233.8 ± 3.4 eggs, respectively.

Khatkar *et al.* (1995) found the egg number upto 40 weeks of age in PL1 and PL2 White Leghorn strains as 84 ± 0.25 and 89 ± 0.21 eggs, respectively.

Pattanayak and Patro (1995) evaluated two strains of White Leghorn and stated that in cage system after 11 generation of selection, the egg number was increased (25 eggs in OY strain and 18 eggs in OT strain) in both the strains.

Chaudhary *et al.* (1997) reported the egg number upto 40 weeks of age in pure and crosses of White Leghorns as 93.5 ± 0.47 and 96.4 ± 0.75 eggs, respectively.

Gupta *et al.* (2000) stated that among pure bred strain MM (43.41 ± 0.79 eggs) and among hybrids MP cross (45.06 ± 0.76 eggs) grown in cages produced maximum number of eggs at 24 to 32 weeks of age.

Laly John *et al.* (2000) recorded that in cage system the egg production upto 280 days in IWN and IWP strains was 93.61 ± 0.80 and 97.48 ± 0.49 eggs, respectively in S15 generation. The average phenotypic response per generation was 1.34 ± 0.54 eggs in IWN strain and 1.30 ± 0.43 eggs in IWP strains, respectively. The responses were found to be significant ($P<0.05$) in both IWN and IWP strains.

Anon (2001) reported that hen housed and hen day egg production of N x P strain cross under deep litter system was 269 and 269.8, respectively. It

was also observed that the birds performed well both under cage system and deep litter systems of rearing.

Brah *et al.* (2001) recorded the egg number upto 40 weeks of age in PL12 and PL21 crosses as 100 ± 1.12 and 102 ± 1.20 eggs, respectively under deep litter system of rearing.

Prabhakaran *et al.* (2001) reported that the hen-housed number in IWN and IWP strains and control population of White Leghorn maintained in cages were 97.89, 91.6 and 94.22, respectively.

Anon (2002) reported that the hen housed and hen day production of N x P strain cross under deep litter system were 279.3 and 288.1, respectively. Under cage system of rearing it was 266.1 and 287.7 eggs, respectively.

Singh *et al.* (2002) recorded that in cages there was no significant difference between the reciprocal crosses for hen-housed egg production. However, the PL21 had consistently higher egg production.

2.4 EGG WEIGHT

Chaudhuri *et al.* (1976) recorded an egg weight of 59.16, 54.84, 56.81 and 56.22 g in L33, L55, L77 and L99 White Leghorn strains, respectively at 38 to 40 weeks of age under cage system of rearing.

Benjamin and Choudary (1977) reported that the mean egg weight in AC, AB, BC, BA, CB, CA and CC crosses housed in deep litter system were 56.24, 56.11, 55.29, 54.62, 55.09, 55.60 and 57.33 g, respectively at 55 weeks of age and found that crosses, those with A strain as male parent had heavier egg weight than those with B and C.

Hamilton (1978) recorded an egg weight of 50.7, 49.7 and 50.0 g in 2 x 3, 3 x 2 and 4 x 1 three two-way crosses of White Leghorn strains, respectively at 165 days of age under cage system.

Nair *et al.* (1979) observed an egg weight of 49.30, 48.50, 50.20 and 48.40 g in 1 x 2, 2 x 1, 1 x 3 and 3 x 1 strain crosses of White Leghorn, respectively at 35 weeks of age. At 55 weeks of age, the egg weights were 51.50, 50.80, 53.10 and 51.10 g, respectively under deep litter system.

Reddy *et al.* (1980) found that the average egg weight in L35, L37, L39, L53, L57, L59, L73, L75, L79, L93, L95 and L97 strain crosses maintained in cages were 52.1, 56.3, 54.7, 57.3, 53.6, 55.9, 55.0, 54.5, 56.3, 54.5, 55.7 and 55.59, respectively at 40 weeks of age.

Fairfull *et al.* (1983) conducted an experiment in six selected strains of White Leghorn (1,3,2,4,9 and 8), thirty strain crosses, best cross (1 x 8), two commercial stocks (A and B) and two control strains (5 and 7) of White Leghorn and recorded an average egg weight of 56.4, 57.4, 57.3, 59.3, 56.8 and 52.7 g in six selected strains, thirty strain crosses, best strain cross, two commercial stocks and two control strains, respectively at 240 days of age reared in single bird cage.

Abplanalp *et al.* (1984) recorded an average egg weight of 47.9 ± 0.2 g in two-line crosses during 24^{th} week of age under cage system of rearing.

Amritha Viswanath *et al.* (1984) reported that the mean egg weight in L21, L22, L23, L31, L33, L32, L11, L12 and L13 strain crosses were 51.080, 53.150, 54.333, 52.729, 53.567, 54.858, 55.000, 55.271 and 52.375 g, respectively. L12 combination registered the highest egg weight, even though there was no significant difference between L12, L32, L23 and L1 and L3 pure strains.

Johari *et al.* (1984) studied the White Leghorn strain cross pullets of six genetic groups (L53, L57, L59, L93, L95 and L97) and observed that mean egg weight in strain crosses were 54.03 and 54.09 g, respectively in cage and floor housing system at 39 to 40 weeks of age.

Pandey *et al.* (1984) reported that the mean egg weight in L33, L55, L77, L99 and control strains were 54.9, 54.2, 55.05, 53.66 and 56.49 g, respectively. Control had significantly higher egg weight than all the four selected strains, however L33, L55 and L77 were not significantly different among themselves.

Verma *et al.* (1984) found that in cage system the heritability of egg weight at 35 weeks of age in pure and strain cross was 0.71 ± 0.23 and 0.83 ± 0.64, respectively.

Giri and Patro (1985) reported that the average egg weight in MxT, TxM, MxV, VxM, VxT and TxV strain crosses were 50.05, 50.20, 52.42, 51.92, 53.65 and 51.07 g, respectively upto 280 days of age.

Dey *et al.* (1987) observed an egg weight of 52.14 and 50.6 g in L-55 x L-33 White Leghorn strain cross and L-55 x Rhode Island Red Cross, respectively at 40 weeks of age.

Goswami and Shukla (1989) utilized the six White Leghorn strain crosses (III, IV, V, VI, VII and VIII) and found the mean egg weight of 52.03 and 52.38 g in strain crosses which reared in cage and deep litter housing system at 40 weeks of age.

Anon (1990) reported that the average egg weight of N x P strain cross was 55.8 g.

Kumararaj *et al.* (1990) recorded an average egg weight of 49 ± 0.22 and 48 ± 0.21 g in Meyer x Forsgate and their reciprocal cross, respectively at 38 to 40 weeks of age.

Mahesh Dutt *et al.* (1990) observed that in cages the initial egg weight was found to be more or less similar in all strain crosses. However 40th week egg weight exceeded in LM and LG crosses.

Yadav *et al.* (1991) reported that mean egg weight at 40 weeks of age in TV and VT White Leghorn strain crosses housed in cages were 50.62 and 50.24 g, respectively.

Sharma *et al.* (1992) observed that in cages the egg weight of reciprocal crosses RIW x RIR, IWH x RIR and IWH x RIW was 49.51 ± 0.39, 47.71 ± 0.38 and 48.31 ± 0.45 g, respectively.

Singh *et al.* (1992) recorded the mean egg weight in two reciprocal crosses PL12 and PL21 as 53.6 ± 0.16 and 53.8 ± 0.15 g, respectively at 36 to 38 weeks of age under cage system of rearing.

Srivastava *et al.* (1993) found the egg weight of IWN and IWP strain at 38-40 weeks of age as 52.7 and 53.8 g, respectively over four generations under cage system.

Chaubal *et al.* (1994) stated that under cage system the DK birds had significantly ($P<0.05$) higher egg weight (55.06 and 53.13 g) than DD birds (53.36 and 52.49 g), while KD birds had lower egg weight (54.67 and 51.46 g) than KK birds (55.22 and 52.17 g) in both S2 and S3 generations, respectively.

Brah *et al.* (1995) recorded an average egg weight of 52.1 ± 0.75 and 53.3 ± 0.27 g in PL12 and PL21 strain crosses, respectively at 38 to 40 weeks of age grown under deep litter system.

Kharadi *et al.* (1995) studied seven strain crosses of White Leghorn (A, B, C, E, F, L and H) and reported that the strain crosses kept in cages produced slightly heavier (50.1 g) eggs than those kept on deep litter (49.8 g) at 68 weeks of age.

Khatkar *et al.* (1995) found the mean egg weight of PL1 and PL2 White Leghorn strains as 52.8 ± 0.09 and 53.0 ± 0.09 g, respectively at 38 to 40 weeks of age.

Pattanayak and Patro (1995) evaluated two strains of White Leghorn and stated that in cage system after 11 generations of selection, egg weight declined (3.60 g in OY and 2.27 g in OT strain) in both strains. However, the decline in egg weight per generation was 0.25 g in OY strain and 0.20 g in OT strain.

Chaudhary *et al.* (1997) observed the average egg weight in pure and crosses of White Leghorn as 51.8 ± 0.08 and 51.8 ± 0.16 g, respectively at 36 to 38 weeks of age.

Padhi *et al.* (1998) assessed the egg quality of different breeds of chicken and recorded the mean egg weight of White Leghorn as 62.86 ± 1.80 g.

Gupta *et al.* (2000) carried out combining ability analysis for egg production and egg weight in progenies of a 3 x 3 diallel cross of White Leghorn and reported that in cage system among pure strains, MM hens laid the heaviest eggs (52.06 ± 0.38 g) and within hybrid genotypes, the maximum egg weight (55.39 ± 0.349) was obtained from MN genotype at 32 weeks of age.

Laly John *et al.* (2000) found the egg weight of IWN and IWP strains in cages at 38 weeks of age as 52.61 ± 0.13 and 52.60 ± 0.09 g, respectively in S15 generation. The average phenotypic response per generation was 0.13 ± 0.05 g in IWN and 0.10 ± 0.04 g in IWP strains, respectively.

Prabhakaran *et al.* (2000) reported that in cage system the egg weight in IWN and IWP strains and a control population of White Leghorn was 50.40, 49.40 and 46.56 g, respectively at 32 weeks of age. At 40 weeks of age it was 52.38, 51.44 and 47.78 g, respectively.

Anon (2001) reported that the average egg weight of N x P strain cross was 55.76 g under deep litter system of rearing.

Brah *et al.* (2001) recorded the average egg weight of PL12 and PL21 crosses as 53.6 ± 0.22 and 54.3 ± 0.26 g, respectively at 34 to 38 weeks of age under deep litter system.

Anon (2002) reported that the average egg weight of N x P strain cross under deep litter system of rearing was 57 g.

Singh *et al.* (2002) stated that in cages the reciprocal cross PL21 had significantly ($P \leq 0.05$) higher egg weight than PL12 in two of three generations.

2.5 FEED CONSUMPTION AND FEED CONVERSION RATIO (FCR)

Nair *et al.* (1979) recorded the FCR of 1.980, 1.990, 2.170 and 2.080 kg of feed per dozen eggs in 1x2, 2x1, 1x3 and 3x1 strain crosses, respectively under deep litter system.

Thiyagasundaram *et al.* (1982b) observed an average feed consumption of 87.72, 94.63, 88.76, 91.69, 94.15 and 98.23 g/bird/day upto 40 weeks of age in L53, L57, L59, L93, L95 and L97 strain crosses, respectively under cage system. The feed per dozen eggs were 1.654, 1.699, 1.574, 1.684, 1.649 and 1.874 kg, respectively, upto 40 weeks of age.

Fairfull *et al.* (1983) conducted an experiment in six selected strains of White Leghorn (1,3,2,4,9 and 8), thirty strain crosses, best cross (1 x 8), two commercial stocks (A and B) and two control strains (5 and 7) of White Leghorn and recorded that feed consumed per kg egg produced were 2.62, 2.50, 2.40, 2.39, 2.71 and 3.11 in six selected strains, thirty strain crosses, best strain cross, two commercial stocks and two control strain, respectively, upto 272 days of age reared in 3 birds per cage.

Abplanalp *et al.* (1984) recorded an average feed consumption of 105.3 ± 2.1 g per bird day in two-line crosses at 24 to 28 weeks of age when grown under cage system of rearing. The feed efficiency was 0.422 ± 0.08 (Kilogram of eggs per kilogram of feed).

Johari *et al.* (1984) studied the White Leghorn strain cross pullets of six genetic groups (L53, L57, L59, L93, L95 and L97) and found that feed per dozen eggs (kg) in strain crosses were 1.74 and 2.12 in cage and floor housing system, respectively.

Dey *et al.* (1987) compared the production traits between the White Leghorn strain cross and White Leghorn x Rhode Island Red cross and found that the annual feed consumption (118.14 and 117.85 g per day) did not differ between the crosses.

Goswami and Shukla (1989) utilized the six White Leghorn strain crosses (III, IV, V, VI, VII and VIII) and found that feed consumption per dozen of eggs in strain crosses were 1687.2 and 1624.7 g which reared in cage and deep litter, respectively upto 40 weeks of age.

Anon (1990) reported that the mean daily feed consumption of N x P strain cross was 105 g. The average feed consumption per dozen of eggs was 1.69 kg.

Kharadi *et al.* (1995) studied seven strain crosses of White Leghorn (A, B, C, E, F, L and H) and reported that the pooled average feed consumption per dozen of eggs for strain crosses in cage and deep litter was 1.97 ± 0.04 and 2.02 ± 0.07 kg, respectively upto 68 weeks of age.

Anon (2001) reported that the average daily feed consumption of N x P strain cross under deep litter system was 129 g. The average feed consumption per dozen of eggs was 2.20 kg.

Anon (2002) reported that the mean daily feed consumption and feed per dozen of eggs of N x P strain cross under deep litter system of rearing were 132 g and 2.12 kg, respectively.

2.6 LIVABILITY

The livability per cent reported by Benjamin and Choudary (1977) in AC, AB, BC, BA, CB, CA and CC crosses maintained in deep litter system were 93.1, 95.7, 92.0, 93.0, 90.8, 94.6 and 93.6, respectively upto 40 weeks of age.

Nair *et al.* (1979) recorded an average livability of 92.50, 84.17, 88.33 and 89.17 per cent in 1x2, 2x1, 1x3 and 3x1 strain crosses, respectively, upto 500 days of age under deep litter system.

Reddy *et al.* (1980) observed that in cage system the livability per cent in L35, L37, L39, L53, L57, L59, L73, L75, L79, L93, L95 and L97 strain crosses were 96.5, 98.4, 98.2, 96.2, 98.3, 96.8, 95.9, 100, 95.8, 100, 96.5 and 98.3, respectively at 20 to 40 weeks of age.

Anon (1990) reported that the laying house mortality of N x P strain cross was less than one per cent per month.

Singh *et al.* (2002) stated that in cages the cumulative mortality from 21 to 40 weeks of age in the two reciprocal crosses (PL12 and PL21) of White Leghorn strain crosses were 9.7 and 10.3 per cent, respectively.

2.7 EGG QUALITY

Reddy *et al.* (1980) obtained the albumen index of 0.094, 0.109, 0.112, 0.101, 0.109, 0.963, 0.109, 0.109, 0.113, 0.108, 0.105 and 0.123 in L35, L37, L39, L53, L57, L59, L73, L75, L79, L93, L95 and L97, respectively under cage system at 40 weeks of age. The yolk index values were 0.433, 0.433, 0.453, 0.427, 0.428, 0.420, 0.430, 0.435, 0.424, 0.441, 0.430 and 0.428, respectively.

The shell thickness averaged 32.6, 36.0, 30.2, 31.1, 30.7, 30.5, 29.0, 28.5, 27.8, 27.7, 29.1 and 27.1 μm, respectively.

Singh and Singh (1982) observed that in cages the egg production upto 40 weeks of age had significant negative ($P<0.05$) correlation with Haugh Unit and albumen index in IWH x IWI and IWI x IWH strain crosses. Positive correlation was observed between egg production and yolk index in both the crosses.

Fairfull *et al.* (1983) conducted an experiment in six selected strains of White Leghorn (1,3,2,4,9 and 8), thirty strain crosses, best cross (1 x 8), two commercial stocks (A and B) and two control strains (5 and 7) of White Leghorn and recorded the Haugh Unit score in six selected strain, thirty strain crosses, best strain cross, two commercial stocks and two control strains were 85.3, 86.1, 85.6, 85.6, 86.0 and 85.5, respectively at 240 days of age reared in single bird cage.

Verma *et al.* (1983) conducted a 4 X 4 diallel crossing involving four strains of White Leghorn (L33, L55, L77 and L99) and recorded the weighted means of yolk index for pure strains and strain crosses housed in cages were 0.4375 and 0.4386, respectively at 40 to 45 weeks of age. The means of albumen index were 0.1099 and 0.1144, respectively. The overall average of 0.2868 mm for shell thickness for strain crosses was not significantly different from the average of pure strains (0.2883 mm). The mean Haugh Unit score was 88.21 in pure strains and 89.40 in strain crosses. Amritha Viswanath *et al.* (1984) observed that in deep litter system the strain combinations revealed higher albumen quality than pure strains. L23 combinations registered highest albumen index (0.094). The yolk index values were 0.415, 0.415, 0.429, 0.512, 0.418, 0.413, 0.418, 0.407 and 0.407 in L21, L22, L23, L31, L33, L32, L11, L12 and L13 strain combinations, respectively at 40 weeks of age. The shell thickness was 0.342, 0.342, 0.344, 0.328, 0.332, 0.343,

0.370, 0.349 and 0.349 respectively. L23 combination recorded maximum Haugh Unit (82.583) score followed by L13 (82.167) and L21 (81.377).

Johari *et al.* (1984) studied the White Leghorn strain cross pullets of six genetic groups (L53, L57, L59, L93, L95 and L97) and reported that the weighted means of albumen index in strain crosses were 0.098 and 0.092 in cage and deep litter housing systems, respectively at 40 weeks of age. The Haugh Unit was 85.726 and 83.234, respectively. The yolk index was 0.469 and 0.473 and the shell thickness was 0.330 and 0.332 mm, respectively.

Pandey *et al.* (1984) found that the albumen index in L33, L55, L77, L99 and control strains were 0.093, 0.096, 0.098, 0.103 and 0.105, respectively at 40 weeks of age. The Haugh Unit scores were 87.53, 88.67, 90.29, 91.31 and 92.11, respectively. The yolk index was 0.449, 0.435, 0.427, 0.418 and 0.437, respectively. No significant difference was observed between strains in shell thickness.

Verma *et al.* (1984) found that in cage system the heritability estimate of yolk index in pure and strain cross was 0.10 ± 0.13 and 0.41 ± 0.19, respectively. The heritability of albumen index was 0.86 ± 0.29 and 0.65 ± 0.21, respectively. The heritability of Haugh Unit score was 0.76 ± 0.27 and 0.64 ± 0.21, respectively and the shell thickness was 0.18 ± 0.15 and 0.40 ± 0.16, respectively.

Kumararaj *et al.* (1990) recorded that shape index of 59.13 and 56.84 in Meyer x Forsgate and Forsgate x Meyer strain crosses, respectively at 38 to 40 weeks of age. The albumen index was 0.07 and 0.07, respectively when reared in breeding pen. The yolk index was 0.379 and 0.378, respectively. The shell thickness was 0.335 and 0.341 mm, respectively.

Kumararaj *et al.* (1994) carried an experiment in Meyer and Forsgate strain of White Leghorn and their reciprocal crosses and stated that the egg weight was found to be positively correlated both phenotypically and genetically with shape index, albumen index and Haugh Unit. Shape index was found to be moderately correlated both genetically and phenotypically with albumen quality and yolk index.

Khatkar *et al.* (1995) found the shell thickness of PL1 and PL2 White Leghorn strains as 0.34 ± 0.08 and 0.357 ± 0.07 mm, respectively at 38 to 40 weeks of age.

Padhi *et al.* (1998) reported the indices of shape, albumen, yolk, Haugh Unit score and shell thickness of White Leghorn as 73.56 ± 1.22, 0.1084 ± 0.01, 0.4388 ± 0.01, 84.52 ± 3.65 and 0.3127 ± 0.01 mm, respectively at 30 weeks of age.

Brah *et al.* (2001) observed that in deep litter system the reciprocal crosses of PL1 and PL2 (PL12 and PL21) did not differ from each other in shell quality.

Materials and Methods

3. MATERIALS AND METHODS

A total of 150 pullets each in N x P and P x N cross from All India Co-ordinated Research Project on Poultry Improvement, Mannuthy Centre was utilized for the study. The birds were housed at 16 weeks of age with three replicates in each strain cross. Fifty birds were randomly allotted in each replicate making of six replicates. The birds were reared under deep litter system of management. Uniform managemental practices were followed in all the replicates. Data were recorded for five periods of 28 days, each from 21 to 40 weeks of age. The records were maintained period-wise.

Experimental birds were fed standard layer mash as per BIS (1993), *ad libitum*. Shell grit was offered *ad libitum* in the pens. The ingredient composition of the feed is presented in Table 1. The proximate composition of the ration was estimated according to procedure described in AOAC (1990) and the per cent proximate composition of nutrients in the layer mash is presented in Table 2.

The following observations were recorded during the course of the experiment.

3.1 BODY WEIGHT

Body weight of birds at 20 and 40 weeks of age was recorded individually to the nearest 10g (BW 20 and BW 40).

3.2 AGE AT SEXUAL MATURITY (ASM)

The age at first egg and age at 50 per cent production (days) were recorded in each replicate and from the data mean age at sexual maturity were determined.

3.3 EGG PRODUCTION

Egg production was recorded daily, from 21 to 40 weeks of age. It was expressed as hen housed and hen day production, replicate wise and period wise.

3.4 EGG WEIGHT

Individual weight of all eggs laid during last three days of each 28-day period was measured to the nearest 0.01 g. The mean egg weight was calculated for each replicate.

3.5 FEED CONSUMPTION

The weight of feed issued was recorded for each replicate. The balance feed available in the feeders at the end of each period was recorded. From this data, period-wise mean daily feed consumption per bird was worked out.

3.6 LIVABILITY

The period-wise per cent livability was recorded based on the number of birds alive during each period.

Table 1. Per cent composition of feed ingredients in the layer mash fed to the experimental birds

Sl. No.	Ingredient	Per cent
1	Yellow maize	36
2	Rice polish	20
3	Wheat bran	10
4	Ground nut oil cake	4
5	Gingelly oil cake	4
6	Soyabean meal	11
7	Dried fish	8
8	Mineral mixture*	1.75
9	Salt	0.25
10	Shell grit	4
11	Dicalcium phosphate	1
	Supplement	(g)
1	Lysine	25
2	Methionine	40
3	Choline chloride	40
4	Nicomix A+B_2+D_3+K**	15

* Supermin P mineral mixture without salt (Kwality Agrovet Industries.,Salem)

Ingredients: Calcium - 30.0%, Phosphorus - 9.0%, Iron - 0.2%, Iodine - 0.01%, Zinc - 0.05%, Manganese - 0.4%, Copper - 0.4%, Fluroine (max) - 0.05%, Acid insoluble ash (max) - 2.5% and moisture - 3%

** Nicomix A+B_2+D_3+K (Nicholas Primal India Ltd., Mumbai)

Composition per gram: Vitamin A - 82,500 IU, Vitamin B_2 - 50mg, Vitamin D_3 - 12,000 IU, Vitamin K - 10mg.

Table 2. Per cent composition of the nutrients in the layer mash (on dry matter basis)

Sl. No.	Ingredient	Per cent
1	Dry matter	88.5
2	Crude protein	18.2
3	Crude fibre	8.15
4	Ether extract	4.1
5	Nitrogen free extract	58.75
6	Total ash	11.3
7	Acid insoluble ash	3.82
8	Calcium	3.12
9	Phosphorus	0.77
10	Calculated ME (kcal/kg)	2630

3.7 EGG QUALITY

Five eggs were collected at random from each replicate at 28, 32, 36 and 40 weeks of age for egg quality studies. The egg quality parameters studied were shape index, yolk index, albumen index, Haugh Unit score and shell thickness. The heights of albumen and yolk were measured by using Ame's tripod stand micrometer. The widths of the yolk and albumen were measured by using hand slide calipers. Shell thickness was measured by using shell thickness measuring gauge to the nearest 0.01 mm.

Shape index, albumen index, yolk index and Haugh Unit scores were recorded by using the following formulae.

$$\text{Shape index} = \frac{\text{Breadth}}{\text{Length}} \times 100$$

$$\text{Albumen index} = \frac{\text{Height of thick albumen}}{\text{Width of the thick albumen}}$$

$$\text{Yolk index} = \frac{\text{Height of yolk}}{\text{Diameter of yolk}}$$

Taking in account of height of thick albumen and weight of whole egg, the Haugh Unit score was calculated using Ame's tripod stand micrometer.

3.8 ECONOMICS

The economics of egg production over feed cost was calculated taking into account the cost of feed ingredients prevailed at the local market.

The data thus obtained were analysed and compared statistically as per the method described by Snedecor and Cochran (1985). All the tests of difference between means were conducted at the five per cent probability level.

Results

4. RESULTS

The results of the experiment to evaluate and compare the production performance of N x P and P x N White Leghorn strain crosses for layer traits under deep litter system are presented in this chapter.

4.1 METEOROLOGICAL PROFILE

The experimental period from 21 to 40 weeks of age was divided into five 28-day periods (I to V) and the meteorological data for each period commencing from 30th December 2003 to 17th May 2004 are presented in Table 3. The mean daily maximum temperature during these periods ranged between 32.6°C (period V) and 36.9°C (period III). The mean maximum temperature during the period I, II and IV were 33.1°C, 34.5°C and 34.7°C, respectively.

The mean daily minimum temperature ranged between 22.5°C and 25°C. The lowest was recorded in Period I (22.5°C) and the highest was observed in period IV (25°C).

The per cent relative humidity (RH) in the forenoon ranged from 69 to 84. The lowest was recorded in period II (69 per cent) and the highest was observed in period IV and V (84 per cent). In period I and III the relative humidity in the forenoon was 70 and 77 per cent, respectively.

The RH in the afternoon ranged from 33 to 65 per cent. The lowest RH was recorded during period III (33 per cent) and the RH during II period was nearer to period III (35 per cent). The highest RH was recorded during period V (65 per cent).

Table 3. Period wise meteorological data of Mannuthy region from December 2003 to May 2004

Period	Month (age in weeks)	Temperature (°C)		Relative humidity (per cent)		Wind velocity (kmph)	Sunshine hours (mean)	Total rainfall (mm)
		Max.	Min.	F.N.	A.N.			
I	Dec. 03 to Jan 04 (21-24)	33.1	22.5	70	42	8.4	9.5	0
II	Jan-Feb (25-28)	34.5	22.6	69	35	6.3	9.4	0
III	Feb-Mar (29-32)	36.9	23.0	77	33	4.8	9.4	0
IV	Mar-Apr (33-36)	34.7	25.0	84	53	4.3	7.4	24.4
V	Apr-May (37-40)	32.6	24.4	84	65	4.2	5.1	369.5

The mean daily sunshine hours during the initial three periods were higher than those recorded in subsequent periods. The mean values ranged from 5.1 (period V) to 9.5 h per day (period I). The mean values of daily wind velocity ranged between 4.2 kmph (period V) to 8.4 kmph (period I). The mean total rainfall for the first three periods was zero. The rainfall recorded in period IV and V was 24.4 mm and 369.5 mm, respectively.

4.2 BODY WEIGHT

The mean body weights recorded at 20^{th} and 40^{th} week of age are presented in Table 4. The overall mean body weight at 20^{th} week of age was 1555.70 ± 0.0045 g in N x P strain cross and 1485.50 ± 0.02 g in P x N strain cross. The mean body weight in different replicates of N x P strain cross varied from 1546.60 ± 0.02 g to 1561.00 ± 0.02 g and in case of P x N strain cross it varied from 1465.30 ± 0.02 g to 1517.00 ± 0.03 g at 20^{th} week of age. The overall mean body weight at 40^{th} week was 1764.10 ± 0.01 g and 1742.30 ± 0.03 g in N x P and P x N strain cross, respectively. The mean body weight in different replicates of N x P strain cross varied from 1745.10 ± 0.02 g to 1779.69 ± 0.02 g and in P x N strain cross it varied from 1698.40 ± 0.02 g to 1788.20 ± 0.03 g at 40^{th} week of age. The body weight at 20^{th} and 40^{th} week of age showed that the N x P strain cross birds were slightly heavier than P x N strain cross during the experimental period. The differences in body weight between N x P and P x N strain cross at 20^{th} week was significant ($P<0.05$). But at 40^{th} week (body weight) the differences in body weight was not significant.

The mean body weight recorded at 20^{th} and 40^{th} week is depicted in Fig. 1 and 2.

Table 4. Mean body weight in N x P and P x N strain crosses, g

Replicate Number	BW 20		BW 40	
	N x P	P x N	N x P	P x N
1	1546.60 ± 0.02	1465.30 ± 0.02	1779.69 ± 0.02	1698.40 ± 0.02
2	1561.00 ± 0.02	1517.00 ± 0.03	1767.50 ± 0.02	1788.20 ± 0.03
3	1559.50 ± 0.02	1474.30 ± 0.02	1745.10 ± 0.02	1740.40 ± 0.02
Overall mean	1555.70 ± 0.0045[a]	1485.50 ± 0.02[b]	1764.10 ± 0.01	1742.30 ± 0.03

The overall mean values carrying different superscripts within the trait differed significantly ($P<0.05$).

Fig. 1. Mean body weight in N x P and P x N strain crosses at 20 weeks of age

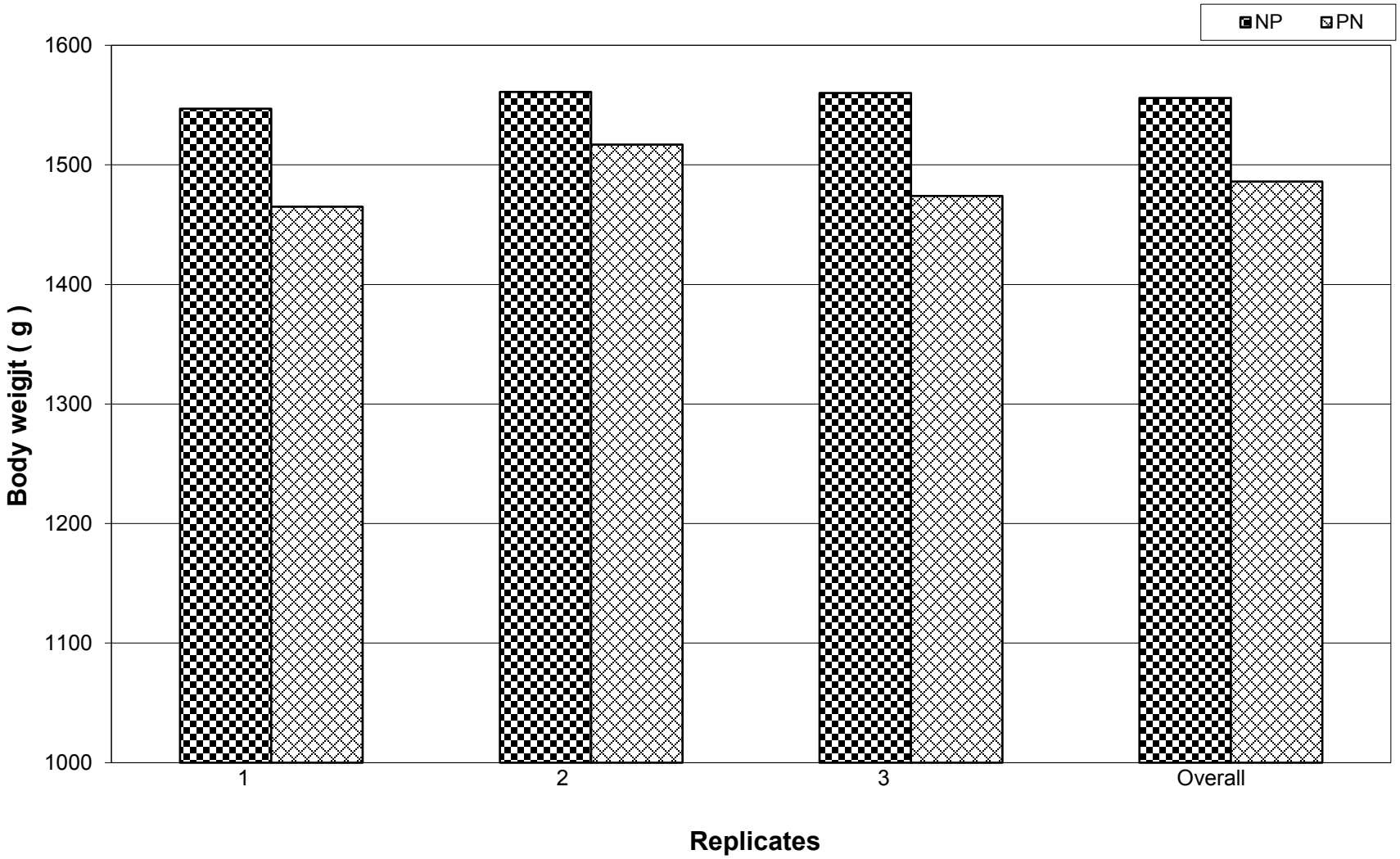
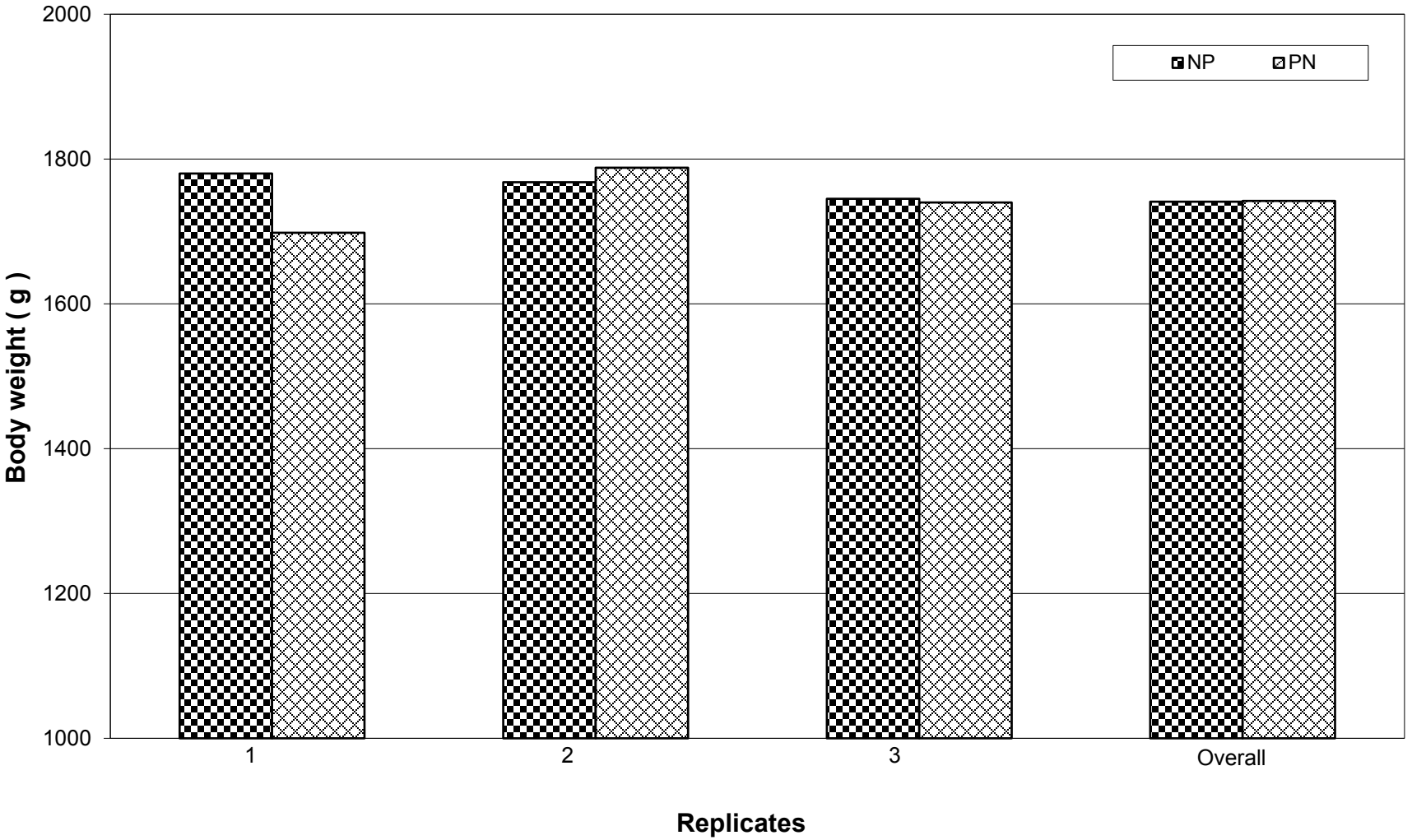


Fig. 2. Mean body weight in N x P and P x N strain crosses at 40 weeks of age



4.3 AGE AT SEXUAL MATURITY

The age at first egg in the flock as well as the age at 50 per cent production are presented in Table 5. The age at first egg ranged from 124 days to 128 days in replicates with an overall mean of 125.67 ± 1.20 days in N x P strain cross whereas in P x N strain cross it varied from 127 days to 130 days with an overall mean of 128.67 ± 0.88 days. These results showed that N x P strain cross started laying three days earlier than P x N strain cross.

The age at 50 per cent production in N x P strain cross was 144 days in all replicates and the overall mean was also same. Whereas in P x N strain cross the age at 50 per cent production in different replicates varied from 143 days to 145 days with an overall mean of 144.33 ± 0.67 days. The overall mean of age at 50 per cent production in both the crosses were same. The age at first egg and age at 50 per cent production showed no significant difference between N x P and P x N strain cross.

4.4 EGG PRODUCTION

4.4.1 Weekly Hen Housed Egg Number (HHN) and Hen Housed Per cent (HHP)

The week-wise mean HHN and HHP in N x P and P x N strain cross are presented in Table 6 and week-wise HHN is depicted in Fig. 3.

The HHN and HHP in N x P strain cross at 21st, 22nd, 23rd and 24th weeks were 3.93 (56.14 per cent), 4.97 (71 per cent), 5.88 (84 per cent) and 6.59 (94.14 per cent), respectively. Whereas in P x N strain cross the HHN and HHP were 3.95 (56.43 per cent), 5.01 (71.57 per cent), 5.76 (82.29 per cent) and 6.39 (91.29

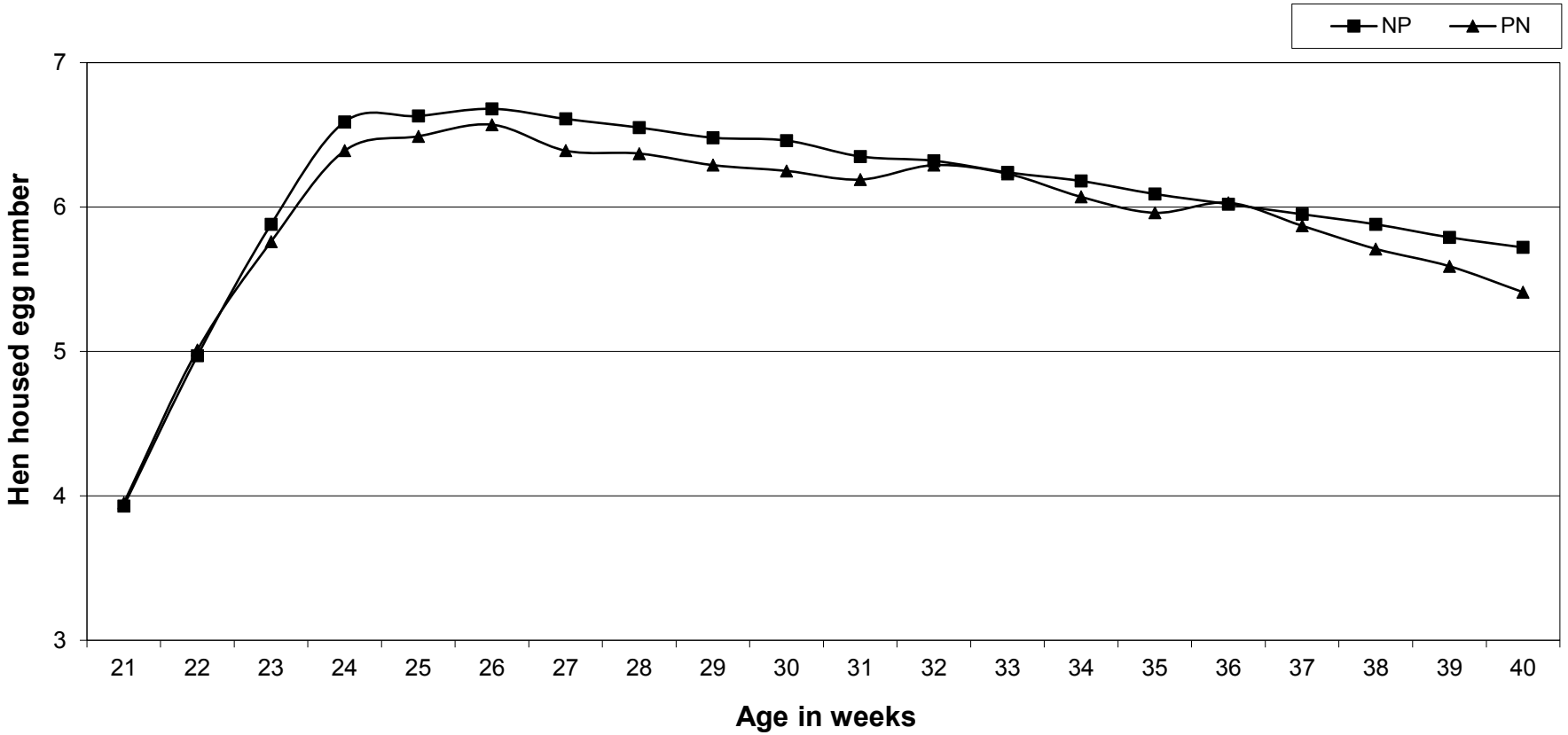
Table 5. Age at sexual maturity in N x P and P x N strain crosses, days

Replicates	Age at first egg (days)		Age at 50 per cent production (days)	
	N x P	P x N	N x P	P x N
1	128	130	144	145
2	125	127	144	143
3	124	129	144	145
Overall mean	125.67 ± 1.20	128.67 ± 0.88	144.00 ± 0.0	144.33 ± 0.67

Table 6. Week-wise mean hen housed egg number and per cent in N x P and P x N strain crosses from 21 to 40 weeks of age

Period	Age in weeks	N x P		P x N	
		HHN	HHP	HHN	HHP
I	21	3.93	56.14	3.95	56.43
	22	4.97	71.00	5.01	71.57
	23	5.88	84.00	5.76	82.29
	24	6.59	94.14	6.39	91.29
II	25	6.63	94.71	6.49	92.71
	26	6.68	95.43	6.57	93.86
	27	6.61	94.43	6.39	91.29
	28	6.55	93.57	6.37	91.00
III	29	6.48	92.57	6.29	89.86
	30	6.46	92.29	6.25	89.29
	31	6.35	90.71	6.19	88.43
	32	6.32	90.29	6.29	91.14
IV	33	6.24	89.14	6.23	89.43
	34	6.18	88.29	6.07	86.71
	35	6.09	87.00	5.96	85.14
	36	6.02	86.00	6.03	86.29
V	37	5.95	85.00	5.87	85.71
	38	5.88	84.00	5.71	81.57
	39	5.79	82.71	5.59	79.86
	40	5.72	81.71	5.41	77.29
Overall	21-40	6.07 ± 0.15	86.66 ± 2.08	5.94 ± 0.14	85.06 ± 1.97

Fig. 3. week - wise mean hen housed egg number in N x P and P x N strain crosses from 21 to 40 weeks of age



per cent), respectively. During this period, the results showed an increasing trend in hen housed egg number and per cent in both the strain crosses.

At 25th week, the HHN in N x P strain cross was 6.63 (94.71 per cent). During 26th week the HHN reached maximum of 6.68 (95.43 per cent). A marginal reduction in HHN was noticed during 27th week with 6.61 (94.43 per cent). HHN reduced at 28th week with 6.55 (93.57 per cent).

The HHN reached 6.48 (92.57 per cent) at 29th week. Thereafter a decreasing trend was noticed at 30th, 31st and 32nd week with 6.46 (92.29 per cent), 6.35 (90.71 per cent) and 6.32 (90.29 per cent), respectively.

The HHN of 6.24 (89.14 per cent) was recorded at 33rd week. A slight decreased trend was observed at 34th week with 6.18 (88.29 per cent). The HHN at 35th week was 6.09 (87.00 per cent). Again a marginal reduction to 6.02 (86.00 per cent) was noticed at 36th week.

The HHN was recorded as 5.95 (85.00 per cent) during 37th week of age. A marginal reduction was noticed during 38th week with 5.88 (84.00 per cent). The HHN during the last two weeks of the experimental study i.e., at 39th and 40th week were 5.79 (82.71 per cent) and 5.72 (81.71 per cent), respectively.

In P x N strain cross the HHN at 25th week of age was 6.49 (92.71 per cent). At 26th week the maximum of 6.57 (93.86 per cent) was recorded. It decreased into 6.39 (91.29 per cent) at 27th week. The HHN of 6.37 (91.00 per cent) was recorded at 28th week.

The HHN at 29th week of age was 6.29 (89.86 per cent). A slight decrease in HHN was observed at 30th week with 6.25 (89.29 per cent). It was

6.19 (88.43 per cent) during 31st week. It rose to 6.29 (91.14 per cent) at 32nd week.

At 33rd week the HHN reached 6.23 (89.43 per cent). During the 34th week the HHN was 6.07 (86.71 per cent). The HHN at 35th and 36th weeks were 5.96 (85.14 per cent) and 6.03 (86.29 per cent), respectively.

A slight decrease in HHN was noticed at 37th week with 5.87 (85.71 per cent). It again decreased to 5.71 (81.57 per cent) at 38th week. The HHN during the last two weeks of experimental study, i.e., 39th and 40th weeks were 5.59 (79.86 per cent) and 5.41 (77.29 per cent), respectively.

The mean HHN from 21 to 40 weeks of age in N x P strain cross was 6.07 ± 0.15 (86.66 ± 2.08 per cent) and in P x N strain cross it was 5.94 ± 0.14 (85.06 ± 1.97 per cent). The mean values did not differ significantly.

4.4.2 Period Wise Hen Housed Egg Number (HHN) and Per cent (HHP)

Period-wise HHN and HHP in N x P and P x N strain crosses are presented in Table 7 and period-wise HHN is depicted in Fig. 4.

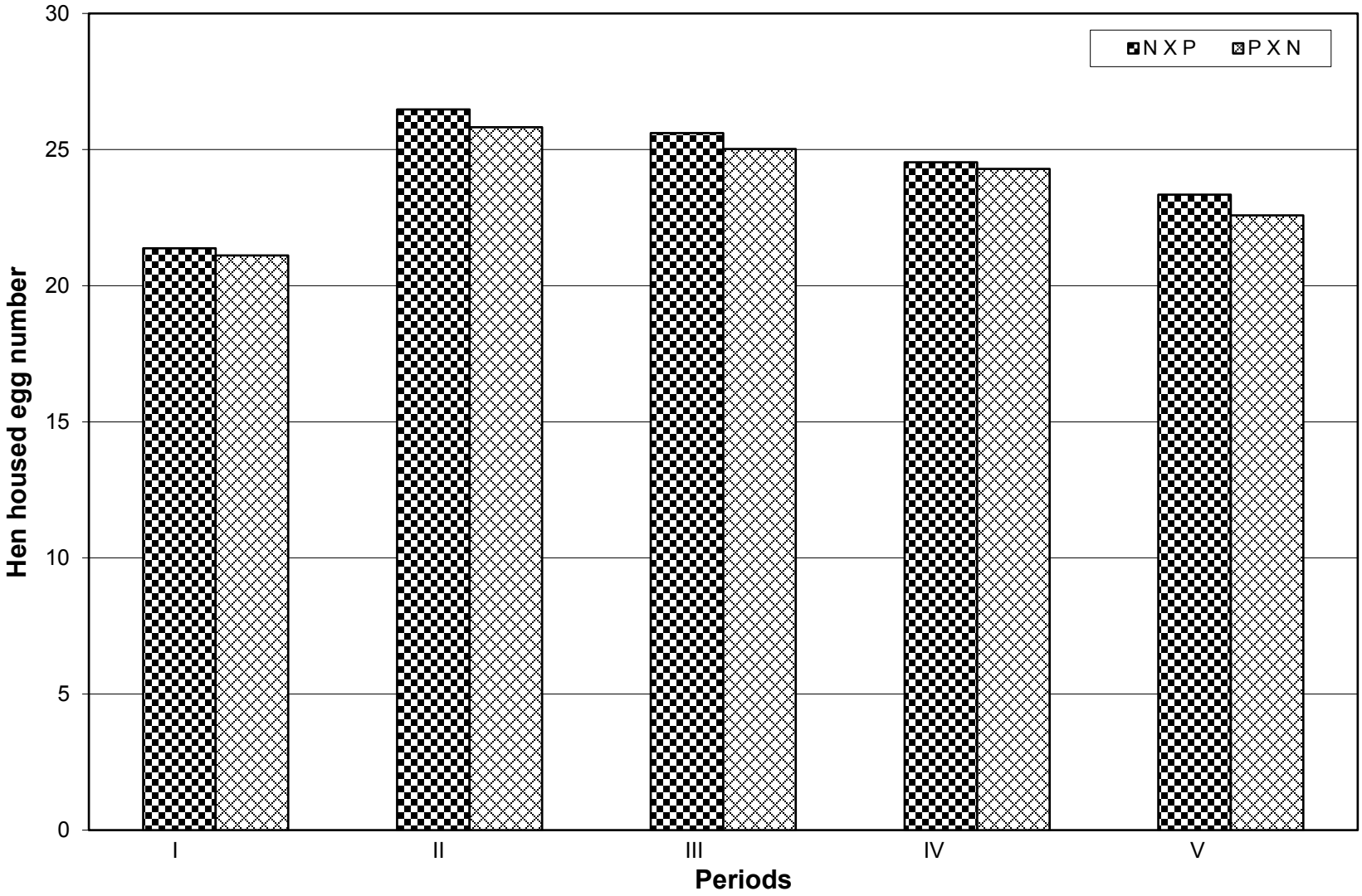
HHN in N x P strain cross during the first period of the experiment was 21.37 (76.32 per cent). During the same period in P x N strain cross it was recorded as 21.11 (75.40 per cent). The difference in HHN between N x P and P x N strain cross was not statistically significant.

During the period II the HHN had reached its peak. It was recorded as 26.47 (94.54 per cent) and 25.82 (92.22 per cent) in N x P and P x N strain crosses, respectively. Though the egg number was higher in both the strain crosses the difference was statistically not significant between the crosses.

Table 7. Period-wise hen housed egg number and per cent in N x P and P x N strain crosses

Period	Age in weeks	N x P		P x N	
		HHN	HHP	HHN	HHP
I	21-24	21.37	76.32	21.11	75.40
II	25-28	26.47	94.54	25.82	92.22
III	29-32	25.61	91.47	25.02	89.68
IV	33-36	24.53	87.61	24.29	86.89
V	37-40	23.34	83.36	22.58	81.11
Overall	21-40	121.32	86.66 ± 3.19	118.82	85.06 ± 3.04

Fig. 4. Period - wise hen housed egg number in N x P and P x N strain crosses



The HHN for the period III in N x P strain cross was 25.61 (91.47 per cent). During the same period the HHN in P x N strain cross was 25.02 (89.68 per cent) and there was no significant difference between the crosses.

During the period IV the HHN was recorded as 24.53 (87.61 per cent) and 24.29 (86.89 per cent) in N x P and P x N strain crosses, respectively and it was not statistically significant.

N x P and P x N strain crosses produced HHN of 23.34 (83.36 per cent) and 22.58 (81.11 per cent), respectively during the last period of experiment and there was no significant difference between them.

The maximum HHN in both N x P and P x N strain crosses recorded were 26.47 (94.54 per cent) and 25.82 (92.22 per cent), respectively and it was during the period II.

N x P strain cross produced a higher HHN of 121.32 (86.66 per cent) compared to P x N strain cross, which had HHN of 118.82 (85.06 per cent) during the entire experimental period and the difference was not significant.

4.4.3 Week-wise Hen Day Number (HDN) and Per cent (HDP)

The week wise HDN and HDP from 21 to 40 weeks are presented in Table 8.

The weekly HDN and HDP from 21 to 28 weeks of age in N x P strain cross was same as that of corresponding HHN and HHP since there was no mortality during this period. The highest weekly HDN recorded was 6.68 (95.43 per cent) at 26^{th} week.

Table 8. Week-wise mean hen day egg number and per cent in N x P and P x N strain crosses from 21 to 40 weeks of age

Period	Age in weeks	N x P		P x N	
		HDN	HDP	HDN	HDP
I	21	3.93	56.14	3.95	56.43
	22	4.97	71.00	5.01	71.57
	23	5.88	84.00	5.76	82.29
	24	6.59	94.14	6.42	91.71
II	25	6.63	94.71	6.53	93.29
	26	6.68	95.43	6.62	94.57
	27	6.61	94.43	6.45	92.14
	28	6.55	93.57	6.46	92.29
III	29	6.48	92.57	6.38	91.14
	30	6.47	92.43	6.33	90.43
	31	6.40	91.43	6.28	89.71
	32	6.36	90.86	6.38	92.43
IV	33	6.32	90.29	6.32	90.57
	34	6.26	89.43	6.18	88.29
	35	6.19	88.43	6.08	86.86
	36	6.17	88.14	6.16	88.57
V	37	6.11	87.29	6.04	86.71
	38	6.04	86.29	5.90	84.29
	39	5.95	85.00	5.78	82.57
	40	5.88	84.00	5.59	79.86
Overall	21-40	6.12 ± 0.14	87.48 ± 2.07	6.03 ± 0.14	86.29 ± 2.00

The HDN at 29th week was 6.48 (92.57 per cent). Due to the death of a bird at 30th week of age, the HDN was 6.47 (92.43 per cent). The HDN and HDP at 31st and 32nd weeks were 6.40 (91.43 per cent) and 6.36 (90.86 per cent), respectively.

The HDN of 6.32 (90.29 per cent) was recorded at 33rd week. During this week one bird died. At 34th, 35th and 36th weeks the HDN were 6.26 (89.43 per cent), 6.19 (88.43 per cent) and 6.17 (88.14 per cent), respectively. During 35th and 36th weeks one bird each died.

The HDN was recorded as 6.11 (87.29 per cent) during 37th week of age. The HDN during the last three weeks of experimental study, i.e., at 38th, 39th and 40th week were 6.04 (86.29 per cent), 5.95 (85.00 per cent) and 5.88 (84.00 per cent), respectively since there was no mortality during this period.

The weekly HDN and HDP from 21 and 23 weeks in P x N strain cross were the same as that of corresponding HHN and HHP. At 24th week the HDN was 6.42 (91.71 per cent). During this week one bird died.

The HDN at 25th week was 6.53 (93.29 per cent). The highest HDN 6.62 (94.57 per cent) was recorded at 26th week. At 27th week the HDN was 6.45 (92.14 per cent). During this week one bird died. The HDN at 28th week was 6.46 (92.29 per cent).

The HDN at 29th, 30th, 31st and 32nd weeks were 6.38 (91.14 per cent), 6.33 (90.43 per cent), 6.28 (89.71 per cent) and 6.38 (92.43 per cent), respectively. During these periods there were no mortality.

The HDN of 6.32 (90.57 per cent) was recorded at 33rd week. At 34th week, the HDN was 6.18 (88.29 per cent). During this week one bird died. The HDN was recorded as 6.08 (86.86 per cent) during 35th week of age. At 36th week the HDN was 6.16 (88.57 per cent). During this week one bird died.

The HDN at 37th week was 6.04 (86.71 per cent). During this week one bird died. The HDN during the last three weeks of experimental study, i.e., at 38th, 39th and 40th weeks were 5.90 (84.29 per cent), 5.78 (82.57 per cent) and 5.59 (79.86 per cent), respectively since there was no mortality during these weeks.

4.4.4 Period-wise Hen Day Number (HDN) and Per cent (HDP)

The period-wise HDN and HDP for N x P and P x N strain crosses are presented in Table 9.

The HDN and HDP for the periods I and II were the same as that of HHN and HHP in N x P strain cross. The highest HDN and HDP were recorded during period II (26.47 and 94.54 per cent, respectively). The HDN and HDP for the period III were 25.71 and 91.82 per cent, respectively. During this period one bird died. The HDN and HDP for the period IV were 24.94 eggs and 89.07 per cent, respectively. During this period three birds died. The HDN and HDP for the last period of experiment were 23.98 eggs and 85.65 per cent, respectively. The overall HDN from 21 to 40 weeks was 122.47.

The HDN and HDP in P x N strain cross for the period I was 21.14 and 75.50 per cent, respectively. During this period one bird died. The highest HDN and HDP were recorded during period II (26.06 and 93.07 per cent, respectively). During this period one bird died. The HDN and HDP recorded at period III were 25.37 (90.93 per cent). The HDN and HDP for the period IV were 24.74 and

Table 9. Period-wise hen day egg number and per cent in N x P and P x N strain crosses

Period	Age in weeks	N x P		P x N	
		HDN	HDP	HDN	HDP
I	21-24	21.37	76.32	21.14	75.50
II	25-28	26.47	94.54	26.06	93.07
III	29-32	25.71	91.82	25.37	90.93
IV	33-36	24.94	89.07	24.74	88.57
V	37-40	23.98	85.65	23.31	83.36
Overall	21-40	122.47	87.48 ± 3.16	120.62	86.29 ± 3.14

88.57 per cent, respectively. During this period two birds died. The HDN and HDP for the last period of experiment were 23.31 eggs and 83.36 per cent, respectively. During this period one bird died. The overall HDN from 21 to 40 weeks was 120.62. The marginal increase of HDN and HDP in N x P strain cross was noticed than P x N strain cross. However, the difference was not significant.

4.5 EGG WEIGHT

The mean egg weight for N x P and P x N strain crosses for the different periods is presented in Table10 and Fig.5.

The mean egg weights of N x P strain cross at 24^{th}, 28^{th}, 32^{nd}, 36^{th} and 40^{th} week were 48.24 ± 0.26, 51.26 ± 0.16, 52.03 ± 0.07, 53.32 ± 0.26 and 55.51 ± 0.18 g, respectively. The overall mean egg weight from 21 to 40 weeks of age was 52.07 ± 1.20 g.

The mean egg weights of P x N strain cross at 24^{th}, 28^{th}, 32^{nd}, 36^{th} and 40^{th} week were 48.76 ± 0.11, 51.34 ± 0.23, 52.99 ± 0.20, 53.62 ± 0.19 and 55.56 ± 0.26 g, respectively. The overall mean egg weight from 21 to 40 weeks was 52.45 ± 1.14 g.

There was significant difference ($P<0.05$) between N x P and P x N strain cross in the mean egg weight for the period III.

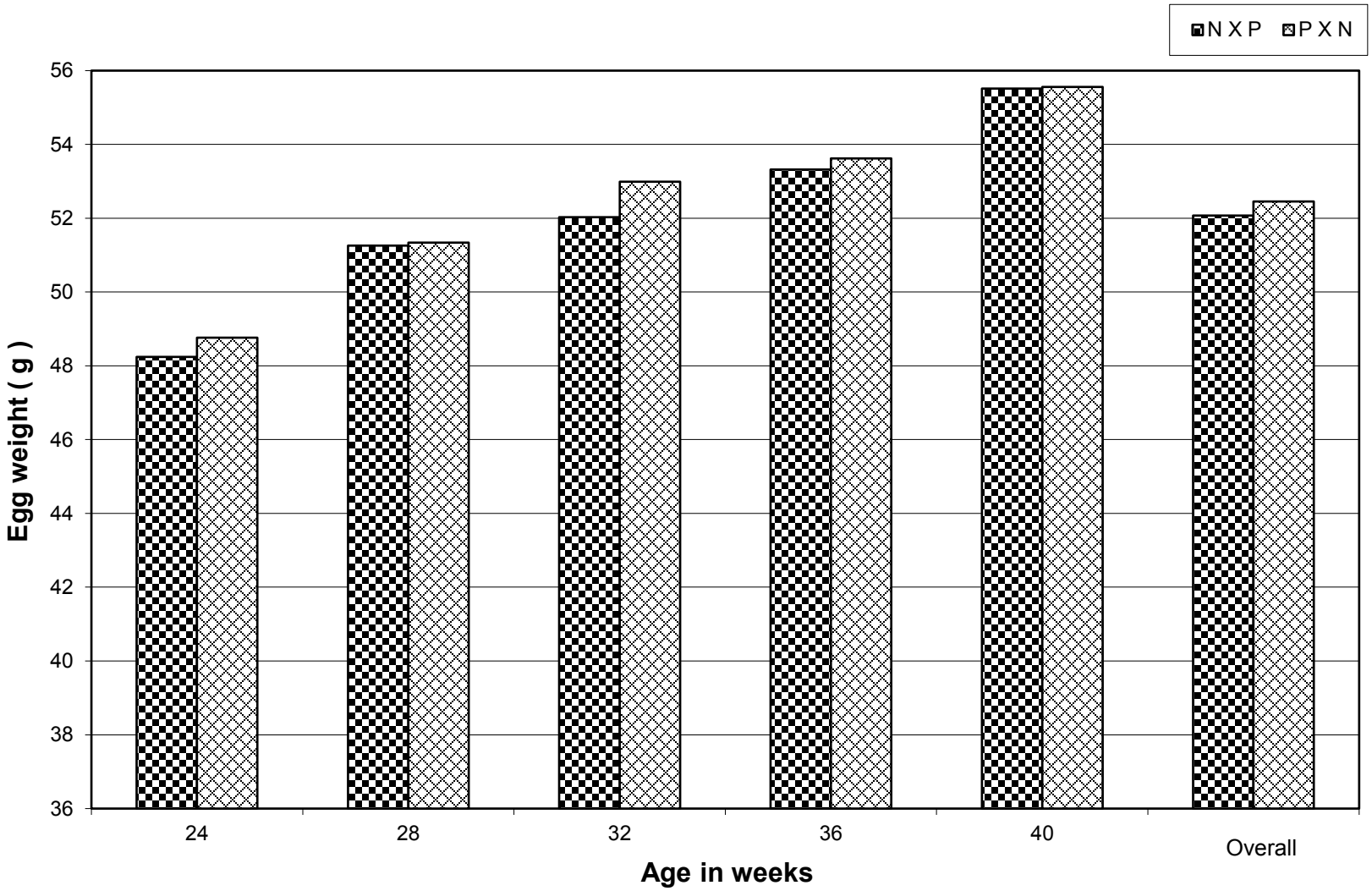
On the other hand, there was no significant difference between N x P and P x N strain cross in the overall mean egg weight.

Table 10. Period-wise mean egg weight in N x P and P x N strain crosses, g

Period	Age in weeks	Egg weight (g)	
		N x P	P x N
I	24	48.24 ± 0.26	48.76 ± 0.11
II	28	51.26 ± 0.16	51.34 ± 0.23
III	32	52.03 ± 0.07[b]	52.99 ± 0.20[a]
IV	36	53.32 ± 0.26	53.62 ± 0.19
V	40	55.51 ± 0.18	55.56 ± 0.26
Overall	21-40	52.07 ± 1.20	52.45 ± 1.14

The mean values carrying different superscripts within a row differed significantly ($P<0.05$).

Fig. 5. Period - wise mean egg weight in N x P and P x N strain crosses



4.6 FEED CONSUMPTION

Mean daily feed consumption in N x P and P x N strain crosses from 21 to 40 weeks is presented in Table 11 and Fig.6 (per bird per day basis).

The mean feed consumption during the period I was 112.59 ± 1.06 g per bird per day for N x P strain cross. The feed consumption from period II to V were 115.55 ± 0.25, 119.02 ± 1.02, 122.43 ± 0.94 and 127.70 ± 0.15 g, respectively. The overall mean daily feed consumption from 21 to 40 weeks was 119.46 ± 2.64 g.

In P x N strain cross the mean daily feed intake during period I was 112.56 ± 1.27 g per bird per day. In subsequent periods the mean daily feed consumption were 117.70 ± 2.89, 118.16 ± 1.47, 121.67 ± 0.83 and 128.29 ± 0.84 g, respectively. The overall mean daily feed consumption from 21 to 40 weeks was 119.68 ± 2.60 g. There was no significant difference between N x P and P x N strain cross in the overall mean daily feed intake as well as in between periods.

4.7 FEED CONVERSION RATIO (FCR)

4.7.1 Feed Conversion Ratio (Per Dozen Eggs)

The mean FCR per dozen eggs in N x P and P x N strain crosses are presented in Table 12 and Fig.7.

The mean FCR in N x P strain cross during the periods I, II, III, IV and V was 1.83 ± 0.19, 1.47 ± 0.05, 1.55 ± 0.05, 1.65 ± 0.02 and 1.79 ± 0.01, respectively. The overall mean FCR from 21 to 40 weeks of age was 1.66 ± 0.07.

Table 11. Mean daily feed consumption in N x P and P x N strain crosses from 21 to 40 weeks of age, g

Period	Age in weeks	Mean daily feed consumption (g)	
		N x P	P x N
I	21-24	112.59 ± 1.06	112.56 ± 1.27
II	25-28	115.55 ± 0.25	117.70 ± 2.89
III	29-32	119.02 ± 1.02	118.16 ± 1.47
IV	33-36	122.43 ± 0.94	121.67 ± 0.83
V	37-40	127.70 ± 0.15	128.29 ± 0.84
Overall	21-40	119.46 ± 2.64	119.68 ± 2.60

Fig. 6. Mean daily feed consumption in N x P and P x N strain crosses from 21 to 40 weeks of age

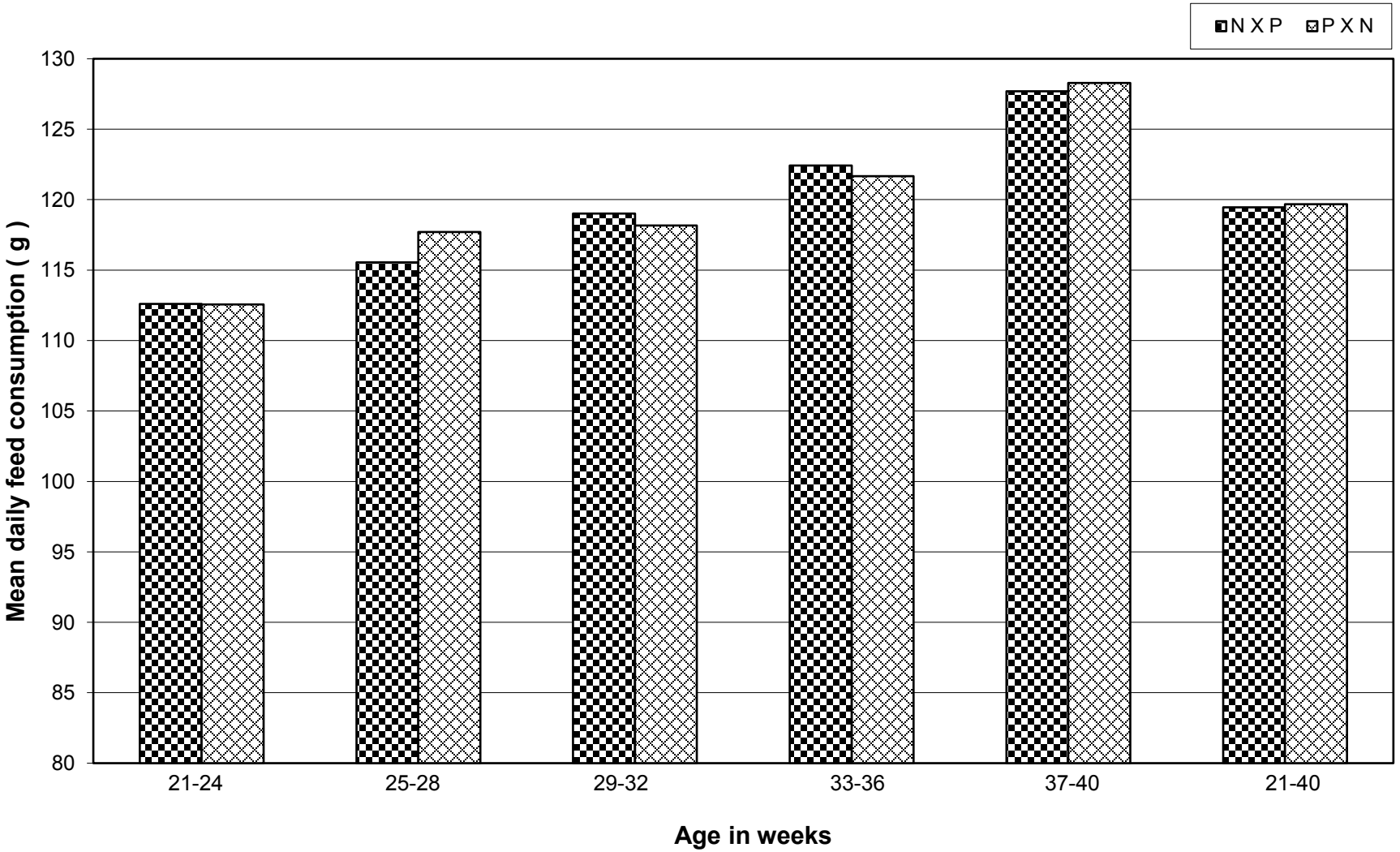
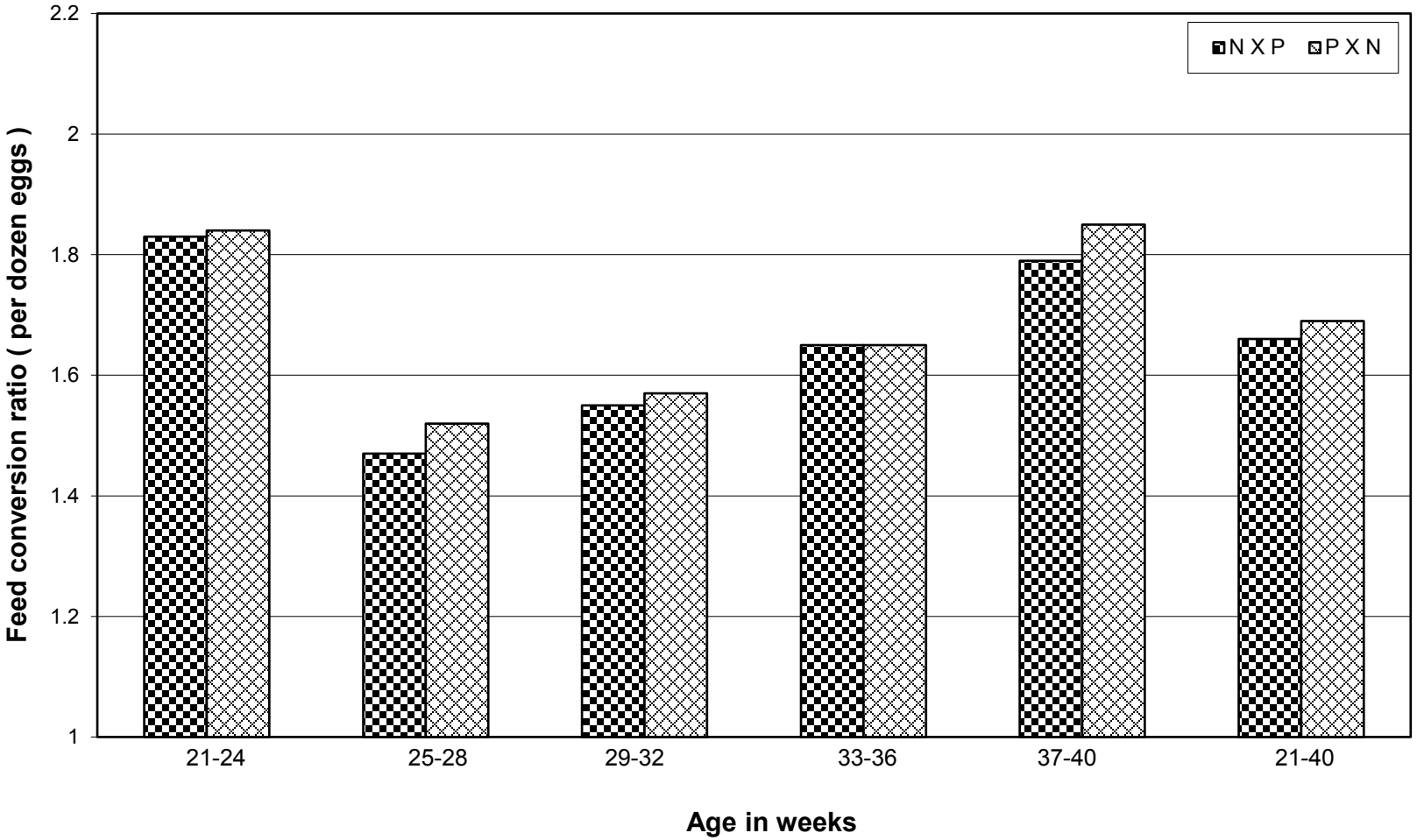


Table 12. Feed conversion ratio in N x P and P x N strain crosses from 21 to 40 weeks of age, per dozen eggs

Period	Age in weeks	Feed conversion ratio (per dozen eggs)	
		N x P	P x N
I	21-24	1.83± 0.19	1.84 ± 0.18
II	25-28	1.47 ± 0.05	1.52 ± 0.03
III	29-32	1.55 ± 0.05	1.57 ± 0.04
IV	33-36	1.65 ± 0.02	1.65 ± 0.04
V	37-40	1.79 ± 0.01	1.85 ± 0.03
Overall	21-40	1.66 ± 0.07	1.69 ± 0.07

Fig. 7. Feed conversion ratio in N x P and P x N strain crosses from 21 to 40 weeks of age



In P x N strain cross the FCR during the periods I, II, III, IV and V were 1.84 ± 0.18, 1.52 ± 0.03, 1.57 ± 0.04, 1.65 ± 0.04 and 1.85 ± 0.03, respectively. The overall mean FCR from 21 to 40 weeks of age was 1.69 ± 0.07.

On comparison between N x P and P x N strain cross birds it was observed that the overall mean FCR did not differ significantly.

4.8 LIVABILITY

The per cent livability in N x P and P x N strain cross birds at different ages from 21 to 40 weeks are presented in Table 13 and Fig.8.

The result showed that overall livability was 97.33 per cent in N x P strain cross and 96.67 per cent in P x N strain cross. The total number of birds died was four in N x P strain cross and five in P x N strain cross during the experimental period. There was no significant difference between N x P and P x N strain cross in livability per cent.

4.9 EGG QUALITY

4.9.1 Egg Quality at 28 Weeks of Age

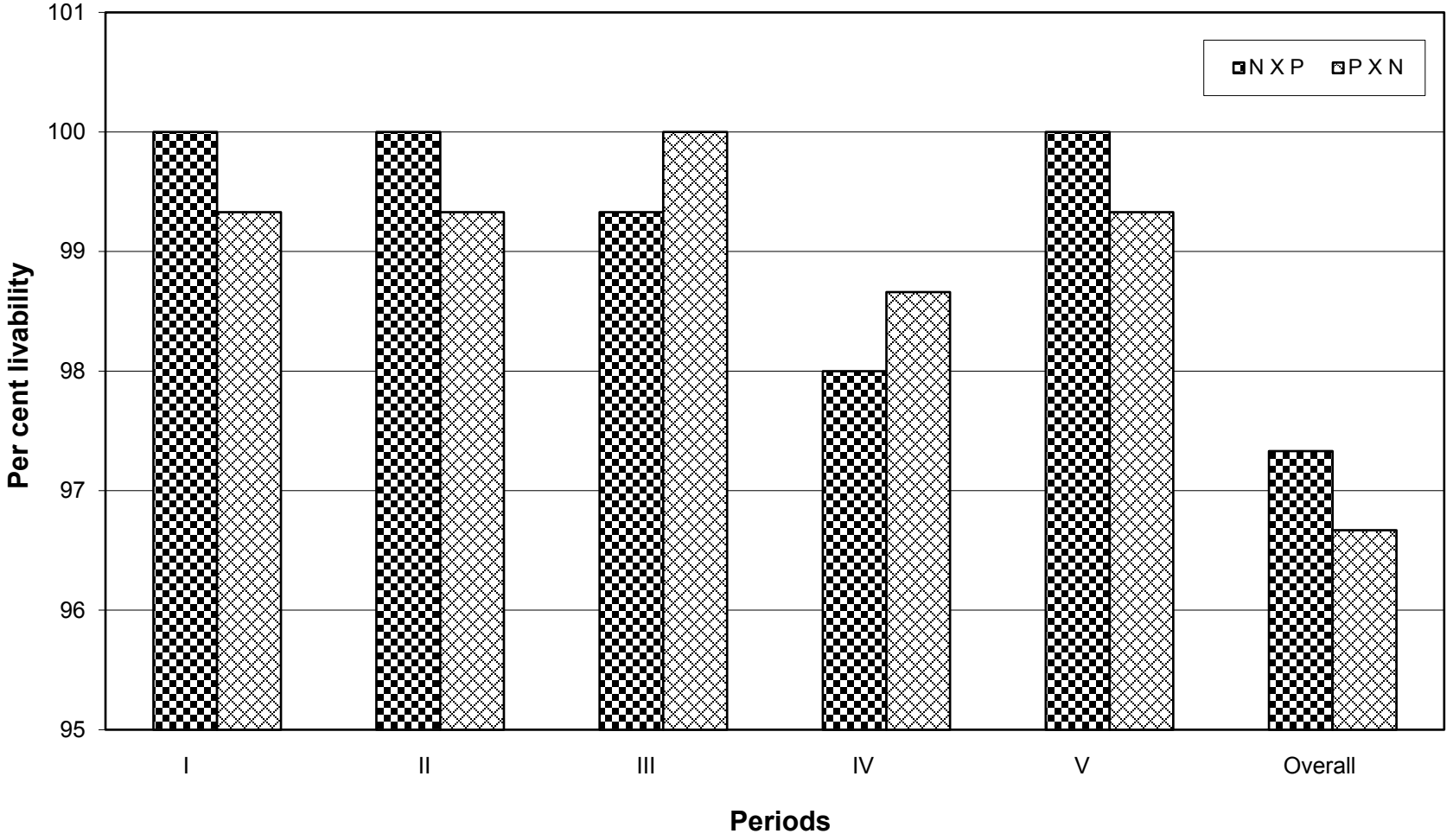
The egg quality traits were measured at 28 weeks of age and the results are presented in Table 14.

The mean shape index of eggs at 28 weeks of age in N x P and P x N strain cross were 75.14 ± 0.68 and 75.88 ± 0.53, respectively. There was no significant difference between N x P and P x N strain cross for shape index at 28 weeks of age.

Table 13. Per cent livability in N x P and P x N strain crosses from 21 to 40 weeks of age

Period	Per cent livability	
	N x P	P x N
I	100.00	99.33
II	100.00	99.33
III	99.33	100.00
IV	98.00	98.66
V	100.00	99.33
Overall 21-40	97.33	96.67

Fig. 8. Per cent livability in N x P and P x N strain crosses from 21 to 40 weeks of age



The mean albumen index for N x P and P x N strain crosses was 0.1029 ± 0.0005 and 0.1083 ± 0.002 and the mean yolk index value was 0.4395 ± 0.005 and 0.4324 ± 0.14, respectively. The mean values of both these indices did not differ statistically.

The mean shell thickness in N x P (0.3612 ± 0.008 mm) and P x N (0.3504 ± 0.01 mm) strain cross did not differ significantly.

The Haugh Unit scores in N x P and P x N strain cross were 91.47 ± 0.41 and 92.00 ± 0.70, respectively and there was no significant difference between them.

4.9.2 Egg Quality at 32 Weeks of Age

The egg quality traits were measured in N x P and P x N strain crosses at 32 weeks of age and the results are presented in Table 15.

The mean shape index of eggs in N x P and P x N strain cross at 32 weeks of age were 77.41 ± 0.09 and 77.22 ± 0.60, respectively. The mean values were compared and no significant difference was noticed between N x P and P x N strain cross.

The mean albumen index for N x P and P x N strain crosses was 0.1055 ± 0.002 and 0.1081 ± 0.002 and the mean yolk index was 0.439 ± 0.013 and 0.4321 ± 0.02, respectively. The mean values of both these indices did not differ statistically.

The mean shell thickness in N x P (0.3586 ± 0.005 mm) and P x N (0.3602 ± 0.002 mm) strain crosses did not differ significantly.

Table 14. Egg quality traits in N x P and P x N strain crosses at 28 weeks of age

Sl. No.	Trait	Egg quality traits	
		N x P	P x N
1.	Shape index	75.14±0.68	75.88 ± 0.53
2.	Albumen index	0.1029 ± 0.0005	0.1083 ± 0.002
3.	Yolk index	0.4395 ± 0.005	0.4324 ± 0.14
4.	Shell thickness (mm)	0.3612 ± 0.008	0.3504 ± 0.01
5.	Haugh Unit score	91.47 ± 0.41	92.00 ± 0.70

Table 15. Egg quality traits in N x P and P x N strain crosses at 32 weeks of age

Sl. No.	Trait	Egg quality traits	
		N x P	P x N
1.	Shape index	77.41±0.09	77.22 ± 0.60
2.	Albumen index	0.1055 ± 0.002	0.1081 ± 0.002
3.	Yolk index	0.439 ± 0.013	0.4321 ± 0.02
4.	Shell thickness (mm)	0.3586 ± 0.005	0.3602 ± 0.002
5.	Haugh Unit score	91.27 ± 0.82	91.73 ± 0.18

The Haugh Unit scores in N x P and P x N strain cross were 91.27 ± 0.82 and 91.73 ± 0.18, respectively and there was no significant difference between them.

4.9.3 Egg Quality at 36 Weeks of Age

The egg quality traits at 36 weeks of age were measured in N x P and P x N strain crosses and the results are presented in Table 16.

The mean shape index for N x P and P x N strain crosses at 36 weeks of age was 77.52 ± 0.82 and 77.97 ± 0.48, respectively and did not differ significantly.

The mean albumen index was 0.1054 ± 0.001 and 0.1149 ± 0.008 and the mean yolk index was 0.4365 ± 0.0005 and 0.44 ± 0.02 in N x P and P x N strain crosses, respectively. The mean values of both these indices did not differ statistically.

The mean shell thickness in N x P (0.3607 ± 0.008 mm) and P x N (0.3563 ± 0.003 mm) strain crosses did not differ significantly.

The Haugh Unit scores in N x P and P x N strain crosses were 90.47 ± 0.07 and 90.87 ± 1.20, respectively and there was no significant difference between them.

4.9.4 Egg Quality at 40 Weeks of Age

The egg quality traits which were measured at 40 weeks of age are presented in Table 17.

Table 16. Egg quality traits in N x P and P x N strain crosses at 36 weeks of age

Sl. No.	Trait	Egg quality traits	
		N x P	P x N
1.	Shape index	77.52 ± 0.82	77.97 ± 0.48
2.	Albumen index	0.1054 ± 0.001	0.1149 ± 0.008
3.	Yolk index	0.4365 ± 0.0005	0.44 ± 0.02
4.	Shell thickness (mm)	0.3607 ± 0.008	0.3563 ± 0.003
5.	Haugh Unit score	90.47 ± 0.07	90.87 ± 1.20

Table 17. Egg quality traits in N x P and P x N strain crosses at 40 weeks of age

Sl. No.	Trait	Egg quality traits	
		N x P	P x N
1.	Shape index	76.06 ± 0.1	75.91 ± 0.67
2.	Albumen index	0.1050 ± 0.003	0.1088 ± 0.002
3.	Yolk index	0.4331 ± 0.002	0.4294 ± 0.002
4.	Shell thickness (mm)	0.3629 ± 0.007	0.3579 ± 0.004
5.	Haugh Unit score	90.40 ± 0.58	90.60 ± 00

The mean shape index at 40 weeks of age in N x P and P x N strain crosses was 76.06 ± 0.1 and 75.91 ± 0.67, respectively. There was no significant difference between them.

The mean albumen index for N x P and P x N strain crosses was 0.1050 ± 0.003 and 0.1088 ± 0.002 and the mean yolk index was 0.4331 ± 0.002 and 0.4294 ± 0.002, respectively and did not differ statistically.

The mean shell thickness for N x P (0.3629 ± 0.007 mm) and P x N (0.3579 ± 0.004 mm) strain crosses did not differ significantly.

The Haugh Unit score in N x P and P x N strain cross was 90.40 ± 0.58 and 90.60 ± 0.00, respectively and there was no significant difference between them.

4.10 ECONOMICS

The economics of egg production over feed cost from 21 to 40 weeks of age is presented in Table 18.

The total feed consumed was 2,481.66 kg in N x P strain cross and 2,478.58 kg in P x N strain cross. The total number of eggs produced during the entire period of experiment was 18,200 in N x P strain cross and 17,823 in P x N strain cross. The feed consumed per egg was 136.35 g in N x P strain cross and 139.06 g in P x N strain cross. The feed cost per egg in N x P strain cross was two paise less than P x N strain cross.

Table 18. Economics of egg production over feed cost from 21 to 40 weeks of age in N x P and P x N strain crosses

Sl. No.	Particulars	N x P	P x N
1.	Feed intake (kg)	2481.66	2478.58
2.	Total number of eggs produced	18200	17823
3.	Feed consumed per egg (g)	136.35	139.06
4.	Cost of feed (Rs./kg)	9	9
5.	Cost of feed per egg (paise)	123	125

Discussion

5. DISCUSSION

An experiment was conducted to evaluate and compare the production performance of reciprocal crosses of two White Leghorn strains (IWN and IWP) under deep litter system. The All India Co-ordinated Research Project on Poultry at Mannuthy Centre is engaged in the pureline breeding with IWN and IWP White Leghorn strains since 1976. Studies to assess the performance of the reciprocal crosses of IWN and IWP under deep litter system of management has not been attempted in Kerala climatic condition. The performance of the two crosses for the various production traits have been discussed.

5.1 METEOROLOGICAL PROFILE

The meteorological data of the experimental period presented in Table 3. revealed that hot and humid conditions prevailed throughout the experimental period. The mean maximum temperature ranged between 32.6°C and 36.9°C. The per cent relative humidity in the forenoon ranged from 69 to 84. The high temperature and humidity might have induced heat stress in the birds.

5.2 BODY WEIGHT

5.2.1 Body Weight at 20 Weeks of Age

The average body weight at 20 weeks of age obtained in this study was 1555.70 ± 0.0045 and 1485.50 ± 0.02 g for N x P and P x N strain crosses, respectively (Table 4). The N x P strain cross showed higher body weight than P x N strain cross ($P<0.05$).

The average body weight recorded in the present study was slightly higher than that reported by Reddy *et al.* (1980), Thiyagasundram *et al.* (1982a), Abplanalp *et al.* (1984), Johari *et al.* (1984), Goswami and Shukla (1989) and Singh *et al.* (1992). The results observed by the above authors ranged between 1050 and 1349 g at 20 weeks of age under cage system of rearing. The higher body weight in this study might be due to strain effect and system of rearing.

Goswami and Shukla (1989) and Brah *et al.* (2002) reported a body weight of 1339.5 and 1020 g, respectively under deep litter system. The values observed in the present study was higher than that reported by the above authors. The differences in body weight might be due to the different strain of White Leghorn crosses.

Laly John *et al.* (2000) reported a body weight of 1248.5 and 1326.80 g for IWN and IWP strains, respectively in S15 generation. Prabhakaran *et al.* (2001) obtained the body weight of 1330 and 1421 g for IWN and IWP strains, respectively. The findings in the present study were higher than that reported by above authors. The higher body weight might be attributed to the reciprocal cross performance of these two strains and the advancement in the generations.

Within the reciprocal crosses significant difference ($P<0.05$) in body weight at 20 weeks of age is in accordance with the findings of Mahesh Dutt *et al.* (1990) and Singh *et al.* (2002). The higher body weight in N x P cross may be due to the usage of IWN strain as male line.

The higher body weight attained in this study over the previous findings might be attributed to the system of rearing, strain effect and the reciprocal cross effects between the strains.

5.2.2 Body Weight at 40 Weeks of Age

The average body weights obtained in the present study at 40 weeks of age were 1764.10 ± 0.01 and 1742.30 ± 0.03 g for N x P and P x N strain crosses, respectively (Table 4). The N x P strain showed slightly higher body weight than P x N cross but the difference was not significant.

Chaudhuri *et al.* (1976) reported a body weight of 1784 g in White Leghorn strain. Reddy *et al.* (1980) obtained a body weight range between 1660 and 1780 g at 40 weeks of age in White Leghorn strains under cage system of rearing. These results are comparable with that obtained in the present study.

The average body weight obtained in this experiment was slightly higher than that reported by Thiyagasundram *et al.* (1982a), Johari *et al.* (1984), Dey *et al.* (1987), Kumararaj *et al.* (1990), Srivastava *et al.* (1993) and Khatkar *et al.* (1995). The higher body weight in the present study might be due to the difference in White Leghorn strains and reciprocal crosses of these strains.

No significant difference in body weight was noticed between these two reciprocal crosses at 40 weeks of age. This is in accordance with the findings of Srivastava *et al.* (1993) and Prabhakaran *et al.* (2001).

It may be noted from the study that body weight character and body weight gain in both the reciprocal crosses were showed the similar trend.

5.3 AGE AT SEXUAL MATURITY

The overall mean age at first egg in N x P and P x N strain crosses was 125.67 ± 1.20 and 128.67 ± 0.88 days, respectively. Similarly, the age at 50 per

cent production was comparable between N x P and P x N strain crosses (Table 5) with mean values of 144.0 ± 0.0 and 144.33 ± 0.67 days, respectively.

Laly John *et al.* (2000) reported that the age at first egg averaged 167 and 159 days for IWN and IWP strains, respectively in S15 generation. Prabhakaran *et al.* (2001) reported that the age at sexual maturity of IWN and IWP strain was 149 and 136 days, respectively. The values found in the present study were lower than that reported by above authors. The lower in age at first egg might be attributed to the reciprocal cross effects of these two strains and intensive selection for this trait.

The age at sexual maturity obtained in the present study was prior to the tune of 20 to 30 days than the reports of Singh *et al.* (1980), Dey *et al.* (1987), Kumararaj *et al.* (1990) and Srivastava *et al.* (1993). The differences in age at first egg in these studies attributed to different White Leghorn strains involved.

The difference between the reciprocal crosses are meagre and not significant. This may indicate that both the crosses are suitable for better egg production as commercial layers.

5.4 EGG PRODUCTION

The data on hen housed egg number, week wise as well as period wise, (Table 6 and Table 7) showed that the hen housed number for N x P and P x N strain crosses upto 40 weeks of age was 121.32 eggs (86.66 ± 3.19 per cent) and 118.82 eggs (85.06 ± 3.04 per cent), respectively. Results indicated a marginal increase in N x P strain cross over P x N strain cross.

Laly John *et al.* (2000) recorded the egg production upto 280 days for IWN and IWP strains as 93.61 ± 0.80 and 97.48 ± 0.49 eggs, respectively in S15

generation under cage system. Prabhakaran *et al.* (2001) reported that the hen-housed number in IWN and IWP strains as 97.89 and 91.6 eggs, respectively upto 40 weeks of age. The results observed in the present study were higher than those reported by above authors. The higher hen housed number might be attributed to the reciprocal cross performance of these two strains, advancement in generations and intensive selection procedures adopted for this trait.

The results obtained in the present study is higher in comparison to those reported by Singh *et al.* (1981), Thiyagasundaram *et al.* (1982b), Giri and Patro (1985), Kumararaj *et al.* (1991), Singh *et al.* (1992) and Brah *et al.* (2001). The results observed by these authors ranged between 43.83 to 104.66 eggs upto 40 weeks of age. The differences in the hen-housed number might be due to different White Leghorn strains involved.

On comparison between the reciprocal crosses revealed that the N x P strain cross birds were superior by 2.5 eggs per bird (Table 7) than P x N strain cross.

The week wise mean hen day number and per cent in N x P and P x N strain crosses were close to the hen housed number and per cent, since the mortality was low.

5.5 EGG WEIGHT

The data on egg weight revealed that the initial egg weight of 48.24 ± 0.26 g gradually increased to 55.51 ± 0.18 g in N x P strain cross at 40 weeks of age (Table 10). In case of P x N strain cross, the initial egg weight was 48.76 ± 0.11 g, which increased to 55.56 ± 0.26 g at 40^{th} week of age.

Under cage system, Laly John *et al.* (2000) recorded the egg weight of IWN and IWP strains as 52.61 ± 0.13 and 52.60 ± 0.09 g, respectively in S15 generation. Prabhakaran *et al.* (2000) reported the egg weight in IWN and IWP strains as 52.38 and 51.44 g at 40 weeks of age. The egg weight obtained in the present study were 3g higher than that reported by above authors. The higher egg weight might be attributed to the reciprocal cross of these two strains and the intensive selection procedures adopted for improvement of strains.

The egg weight at 40 weeks of age obtained in the present study was higher than that reported by Johari *et al.* (1984), Giri and Patro (1985), Dey *et al.* (1987), Goswami and Shukla (1989), Kumararaj *et al.* (1990) and Yadav *et al.* (1991). The results observed by these authors ranged between 48.21 to 54.09 g. The differences in egg weight reported by these workers might be due to strain effect.

5.6 FEED CONSUMPTION

The mean daily feed consumption data (Table 11) indicated a similar feed intake in N x P (119.46 ± 2.64 g) and P x N strain crosses (119.68 ± 2.60 g).

Thiyagasundaram *et al.* (1982b) observed an average feed consumption of 87.72, 94.63, 88.76, 91.69, 94.15 and 98.23 g/bird/day upto 40 weeks of age for L53, L57, L59, L93, L95 and L97 strain crosses, respectively under cage system. The valves observed in the present study were higher than that reported by above authors. Anon (1990) indicated a mean daily feed consumption of 105 g in N x P strain cross which is lower than the result obtained from this study. The increase in feed consumption in the present study might be due to difference in the period of study.

A mean daily feed consumption of 129 g was observed in N x P cross under deep litter system (Anon, 2001). In other experiment a mean daily feed consumption of 132 g was observed in N x P strain cross under deep litter system (Anon, 2002). The values observed in the present study were lower than above findings.

5.7 FEED CONVERSION RATIO (FCR)

The data on feed conversion ratio (per dozen eggs) showed in Table 12. The results revealed that the feed conversion ratio was high during the initial period when the birds where in the start of production, but improved to acceptable values from the second period onwards. The overall mean FCR (per dozen eggs) from 21-40 weeks of age was 1.66 ± 0.07 and 1.69 ± 0.07 in N x P and P x N strain crosses, respectively.

Thiyagasundaram *et al.* (1982b) recorded an average feed per dozen eggs as 1.654, 1.699, 1.574, 1.684, 1.649 and 1.874 kg for L53, L57, L59, L93, L95 and L97 strain crosses, respectively upto 40 weeks of age. Goswami and Shukla (1989) found that feed consumption per dozen of eggs in strain crosses were 1687.2 and 1624.7 g in cage and deep litter, respectively. These results are comparable with the FCR obtained in this study.

Anon (1990) reported an FCR (per dozen eggs) value of 1.69 kg, which was in agreement with the findings of the present study. In other two experiments Anon (2001) and Anon (2002) observed an FCR (per dozen eggs) values of 2.20 and 2.12 kg, respectively which was higher than that obtained from this study. The increase might be due to the period of study.

5.8 LIVABILITY

The data on livability (Table 13) showed an excellent performance of the crosses for this trait. The overall livability was 97.33 and 96.67 per cent for N x P and P x N strain crosses, respectively. Mortality was mainly due to cannibalism.

The livability per cent reported by Benjamin and Choudary (1977) for AC, AB, BC, BA, CB, CA and CC crosses were 93.1, 95.7, 92.0, 93.0, 90.8, 94.6 and 93.6, respectively. The livability percentage reported by the above authors was lower compared to the present study.

The livability per cent observed in the present study was lower than the reports of Reddy *et al.* (1980). The per cent mortality observed in the present study was less than one per month, which was in agreement with the report of Anon (1990).

5.9 EGG QUALITY

The egg quality traits at 28, 32, 36 and 40 weeks of age were almost similar in both N x P and P x N strain crosses (Table 14 to Table 17).

The mean shape index recorded in N x P and P x N strain crosses at 28 weeks of age was 75.14 ± 0.68 and 75.88 ± 0.53, respectively and at 32 weeks of age it was 77.41 ± 0.09 and 77.22 ± 0.6, respectively. The values were 77.52 ± 0.82 and 77.97 ± 0.48 at 36^{th} week and 76.06 ± 0.1 and 75.91 ± 0.67 at 40^{th} week, respectively. The result obtained in the present study was found to be higher than that reported by Kumararaj *et al.* (1990) and Padhi *et al.* (1998).

Albumen index recorded in N x P and P x N strain crosses averaged 0.1029 ± 0.0005 and 0.1083 ± 0.002, respectively at 28 weeks of age. During 32nd week it was 0.1055 ± 0.002 and 0.1081 ± 0.002, respectively. The values were 0.1054 ± 0.001 and 0.1149 ± 0.008 at 36th week and 0.1050 ± 0.003 and 0.1088 ± 0.002 at 40th week, respectively. Though the values were numerically different, there was no significant difference between the groups. The albumen index obtained in the present study was higher than that found in the studies of Amritha Viswanath *et al.* (1984), Johari *et al.* (1984) and Kumararaj *et al.* (1990) and in agreement with Verma *et al.* (1983) and Padhi *et al.* (1998).

The yolk index recorded in the experiment was 0.4395 ± 0.005 and 0.4324 ± 0.14 for N x P and P x N strain cross, respectively at 28 weeks of age and at 32 weeks of age it was 0.439 ± 0.013 and 0.4321 ± 0.02. The values were 0.4365 ± 0.0005 and 0.44 ± 0.02 at 36th week and 0.4331 ± 0.002 and 0.4294 ± 0.002 at 40th week, respectively. The result obtained in the present study was in agreement with those reported by Reddy *et al.* (1980), Verma *et al.* (1983) and Pandey *et al.* (1984) and higher to the values reported by Kumararaj *et al.* (1990).

Shell thickness in N x P and P x N strain crosses was 0.3612 ± 0.008 and 0.3504 ± 0.01 mm at 28 weeks of age, respectively. During 32nd week, it was 0.3586 ± 0.005 and 0.3602 ± 0.002 mm, respectively. The values were 0.3607 ± 0.008 and 0.3563 ± 0.003 mm at 36th week and 0.3629 ± 0.007 and 0.3579 ± 0.004 mm at 40th week, respectively. There was no significant difference between the crosses. The shell thickness obtained in the present study was higher than that reported by Reddy *et al.* (1980), Verma *et al.* (1983), Kumararaj *et al.* (1990) and Padhi *et al.* (1998).

The Haugh Unit scores obtained in the experiment were 91.47 ± 0.41 and 92.00 ± 0.70 for N x P and P x N strain crosses, respectively at 28 weeks of age and the same were 91.27 ± 0.82 and 91.73 ± 0.18 at 32nd weeks of age,

respectively. At 36th weeks it was 90.47 ± 0.07 and 90.87 ± 1.20 and at 40th week it was 90.40 ± 0.58 and 90.60 ± 0.00, respectively.

The values obtained in the study were higher than that reported by Fairfull *et al.* (1983), Amritha Viswanath *et al.* (1984), Johari *et al.* (1984) and Padhi *et al.* (1998). The difference may be due to effect of strain cross and the seasons of measurement.

5.10 ECONOMICS

Feed consumed per egg in N x P strain cross (136.35 g) was lower than P x N strain cross (139.06 g) as indicated in Table 18. The cost of feed per egg in N x P strain cross (123 paise) was also lower than that of P x N strain cross (125 paise). It was due to lower feed consumption in N x P strain cross.

From the above findings it is evident that N x P strain cross birds excelled in body weight, egg production and feed conversion ratio. In all other traits the N x P strain cross equaled the P x N strain cross. All these characters make the N x P strain cross birds more suitable for higher egg production than P x N strain cross under deep litter system.

Summary

6. SUMMARY

An experiment was conducted at the All India Co-ordinated Research Project on Poultry Improvement, Mannuthy Centre to evaluate and compare the production performance of N x P and P x N White Leghorn strain crosses in deep litter system of rearing.

One hundred and fifty (150) pullets of each N x P and P x N strain crosses at the age of 16 weeks were housed in identical pens with three replicates in each strain cross at the rate of 50 birds per replicate. Layer mash with BIS specifications was fed throughout the experimental period. Standard routine management practices were rendered to all the experimental groups during study period. The experimental period ranged from 21 to 40 weeks of age and the production performance of birds for five periods of 28-days each were recorded during the period from December, 2003 to May, 2004. Data were analysed statistically and the following results were obtained.

1. The mean body weight (BW) at 20 weeks of age was 1555.70 ± 0.0045 g in N x P strain cross and 1485.50 ± 0.02 g in P x N strain cross and the BW at 40 week was 1764.10 ± 0.01 g in N x P strain cross and 1742.30 ± 0.03 g in P x N strain cross. Body weight of N x P strain cross was significantly higher than that of P x N strain cross at 20 weeks of age ($P<0.05$).

2. The age at sexual maturity estimated as age at first egg and age at 50 per cent production revealed that the mean values were 125.67 ± 1.20 days and 144.00 ± 0.00 days in N x P strain cross and 128.67 ± 0.88 days and 144.33 ± 0.67 days in P x N strain cross, respectively.

3. The overall mean weekly HHN from 21-40 weeks of age was 6.07 ± 0.15 in N x P strain cross and 5.94 ± 0.14 in P x N strain cross with HHP of 86.66 ± 2.08 and 85.06 ± 1.97, respectively and the difference was not statistically significant.

4. The overall mean weekly HDN was 6.12 ± 0.14 and 6.03 ± 0.14 with a corresponding HDP of 87.48 ± 2.07 and 86.29 ± 2.00 in N x P and P x N strain crosses, respectively and the difference was statistically non-significant.

5. The highest weekly HHN of 6.68 and 6.57 with corresponding percentages of 95.43 and 93.86 were recorded at the age of 26th week in N x P and P x N strain crosses, respectively.

6. The overall mean egg weight recorded during the period from 21 to 40 weeks of age was 52.07 ± 1.20 g and 52.45 ± 1.14 g in N x P and P x N strain crosses, respectively and the difference was not statistically significant.

7. The overall mean daily feed consumption during the period from 21 to 40 weeks of age was 119.46 ± 2.64 g in N x P strain cross and 119.68 ± 2.60 g in P x N strain cross and the difference between the genetic groups was statistically non-significant.

8. The overall mean feed conversion ratio on the basis of dozen eggs from 21 to 40 weeks of age was 1.66 ± 0.07 and 1.69 ± 0.07 in N x P and P x N strain cross, respectively.

9. The overall livability in N x P and P x N strain crosses was 97.33 and 96.67 per cent, respectively.

10. The overall mean shape index in N x P and P x N strain crosses at 28 weeks age was 75.14 ± 0.68 and 75.88 ± 0.53, respectively. At 32nd week it was 77.41 ± 0.09 and 77.22 ± 0.6, respectively. The values were 77.52 ± 0.82 and 77.97 ± 0.48 at 36th week and 76.06 ± 0.1 and 75.91 ± 0.67 at 40th week, respectively and the difference was not statistically significant.

11. The overall albumen index was 0.1029 ± 0.0005 and 0.1083 ± 0.002 in N x P and P x N strain crosses at 28 weeks of age, respectively. During 32nd week it was 0.1055 ± 0.002 and 0.1081 ± 0.002, respectively. The values were 0.1054 ± 0.001 and 0.1149 ± 0.008 at 36th week and 0.1050 ± 0.003 and 0.1088 ± 0.002 at 40th week, respectively and the figures did not differ significantly.

12. The overall mean yolk index in N x P and P x N strain crosses was 0.4395 ± 0.005 and 0.4324 ± 0.14 at 28 weeks of age, respectively and at 32 weeks of age it was 0.439 ± 0.013 and 0.4321 ± 0.02. The values were 0.4365 ± 0.0005 and 0.44 ± 0.02 at 36th week and 0.4331 ± 0.002 and 0.4294 ± 0.002 at 40th week, respectively and statistically they were similar.

13. The overall mean shell thickness in N x P and P x N strain crosses at 28 weeks of age was 0.3612 ± 0.008 and 0.3504 ± 0.01 mm, respectively and at 32 weeks of age it was 0.3586 ± 0.005 and 0.3602 ± 0.002 mm, respectively. At 36th week it was 0.3607 ± 0.008 and 0.3563 ± 0.003 mm and at 40th week it was 0.3629 ± 0.007 and 0.3579 ± 0.004 mm, respectively and the difference was non-significant.

14. The mean value of Haugh Unit score was 91.47 ± 0.41 and 92.00 ± 0.70 in N x P and P x N strain cross, respectively at 28th week of age and it was 91.27 ± 0.82 and 91.73 ± 0.18, respectively at 32nd week. At 36th week it

was 90.47 ± 0.07 and 90.87 ± 1.20 and 90.40 ± 0.58 and 90.60 ± 0.00 at 40^{th} week, respectively and they were statistically similar.

15. The feed cost per egg was 123 paise in N x P strain cross and 125 paise in P x N strain cross.

From the above findings, it could be observed that N x P strain cross birds excelled in body weight, egg production and feed conversion ratio. In all other traits the N x P strain cross equalled the P x N strain cross. All these characters make the N x P strain cross birds more suitable for higher egg production than P x N strain cross birds under deep litter system.

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PRODUCTION PERFORMANCE OF RECIPROCAL CROSSES OF WHITE LEGHORN STRAINS UNDER DEEP LITTER SYSTEM

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ABSTRACT

An experiment was conducted at the All India Co-ordinated Research Project on Poultry Improvement, Mannuthy Centre to evaluate and compare the production traits of N x P and P x N strain crosses under farm conditions. One hundred and fifty pullets of each strain cross were housed in identical pens with fifty birds in each and production performance was evaluated for five periods (each 28 day) from 21 to 40 weeks of age. Standard feeding and managemental practices were followed throughout the study.

The N x P strain cross birds were heavier than P x N strain cross at 20 and 40 weeks of age. The mean body weight for N x P and P x N strain cross was 1555.70 ± 0.0045 g vs. 1485.50 ± 0.02 g and 1764.10 ± 0.01 g vs. 1742.30 ± 0.03 g at 20 and 40 weeks of age, respectively. The age at first egg was 125.67 ± 1.20 days in N x P strain cross and 128.67 ± 0.88 days in P x N strain cross. The age at 50 per cent production was 144.00 ± 0.0 days in N x P strain cross and 144.33 ± 0.67 days in P x N strain cross. The overall mean hen housed number upto 40 weeks of age was 121.32 in N x P and 118.82 in P x N strain cross. The hen day production was 122.47 in N x P and 120.62 in P x N strain cross. The overall mean egg weight was 52.07 ± 1.20 g in N x P and 52.45 ± 1.14 g in P x N strain cross.

The mean daily feed consumption from 21 to 40 weeks of age was 119.46 ± 2.64 g in N x P and 119.68 ± 2.60 g in P x N strain cross. The feed conversion ratio was 1.66 ± 0.07 (per dozen eggs) in N x P strain cross and 1.69 ± 0.07 (per dozen eggs) in P x N strain cross. The shape index was 75.14 ± 0.68, 77.41 ± 0.09, 77.52 ± 0.82 and 76.06 ± 0.1 at 28, 32, 36 and 40 weeks of age in N x P strain cross and in P x N strain crosses it was 75.88 ± 0.53, 77.22 ± 0.6, 77.97 ± 0.48 and 75.91 ± 0.67, respectively. The albumen index was 0.1029 ± 0.0005,

0.1055 ± 0.002, 0.1054 ± 0.001 and 0.1050 ± 0.003 at 28, 32, 36 and 40 weeks of age in N x P strain cross and it was 0.1083 ± 0.002, 0.1081 ± 0.002, 0.1149 ± 0.008 and 0.1088 ± 0.002 in P x N strain cross. The yolk index was 0.4395 ± 0.005, 0.439 ± 0.013, 0.4365 ± 0.0005 and 0.4331 ± 0.002 in N x P strain cross and it was 0.4324 ± 0.14, 0.4321 ± 0.02, 0.44 ± 0.02 and 0.4294 ± 0.002 in P x N strain cross at 28, 32, 36 and 40 weeks of age, respectively. The shell thickness was 0.3612 ± 0.008 mm, 0.3586 ± 0.005 mm, 0.3607 ± 0.008 mm and 0.3629 ± 0.007 mm in N x P strain cross and 0.3504 ± 0.01 mm, 0.3602 ± 0.002 mm, 0.3563 ± 0.003 mm and 0.3579 ± 0.004 mm in P x N strain cross. The Haugh Unit score was 91.47 ± 0.41, 91.27 ± 0.82, 90.47 ± 0.07 and 90.40 ± 0.58 in N x P strain cross and 92.00 ± 0.70, 91.73 ± 0.18, 90.87 ± 1.20 and 90.60 ± 0.0 in P x N strain cross. The livability was 97.33 per cent in N x P strain cross and 96.67 per cent in P x N strain cross. The cost of feed consumed per egg was 123 paise in N x P strain cross and 125 paise in P x N strain cross. From the results it could be concluded that N x P strain cross birds excelled in body weight, egg production and feed conversion ratio. In all other traits the N x P strain cross equalled the P x N strain cross. All these characters make the N x P strain cross birds more suitable for higher egg production than P x N strain cross birds under deep litter system.