STUDIES ON COMPARATIVE PERFORMANCE OF THREE CROSSBRED CHICKENS SUITABLE FOR RURAL FARMING

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DEDICATED

TO MY BELOVED

"FATHER & MOTHER"

&

"FAMILY MEMBERS"

ABSTRACT

STUDIES ON COMPARATIVE PERFORMANCE OF THREE CROSSBRED CHICKENS SUITABLE FOR RURAL FARMING

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ABSTRACT

The present research work was undertaken to evaluate and compare performance of three crossbreds which were generated by mating of males of Australorp (A), Naked neck (Na) and Rhode Island Red (RIR) with the White Leghorn females (IWP strain). The traits studied during the experimental period were fertility, hatchability, body weight, age at first egg, egg production, egg weight, egg mass, feed consumption, feed efficiency, egg quality, livability and economic returns.

The fertility percent was found to be 97.83, 96.33 and 95.83 in Australorp male x IWP strain of White Leghorn female (A x IWP), Naked neck male x IWP strain of White Leghorn female (Na x IWP) and RIR male x IWP strain of White Leghorn female (RIR x IWP) crossbreds, respectively. The hatchability percent on total egg set basis was found to be 92.33, 90.50 and 86.83 and on fertile egg set basis it was found to be 94.37, 93.94 and 90.60 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. Fertility as well as hatchability in A x IWP crossbred was better as compared to Na x IWP and RIR x IWP crossbreds.

The body weight (g) was found to be significantly ($P<0.05$) higher in A x IWP crossbred at all ages as compared to Na x IWP and RIR x IWP crossbreds, except at day old age.

The age at 10% and 50% egg production was higher in A x IWP crossbred as compared to Na x IWP and RIR x IWP crossbreds. The average age at first egg was found to be 157.68 ± 0.65, 153.71 ± 0.36 and 153.56 ± 0.39 days in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. The average age at first egg was significantly ($P<0.05$) higher in A x IWP crossbred as compared to Na x IWP and RIR x IWP crossbreds.

The hen housed egg production was found to be 65.70, 72.67 and 70.00 percent in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. The hen day egg production percent was 67.52, 73.45 and 71.32 for A x IWP, Na x IWP and RIR x IWP crossbreds, respectively.

Mean egg production (No) up to 40 weeks of age (TEN_{40}) was recorded to be 96.11 ± 1.28, 103.54 ± 1.26 and 101.86 ± 1.26 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. The TEN_{40} was significantly ($P<0.05$) higher in Na x IWP and RIR x IWP crossbreds as compared to A x IWP crossbreds.

Mean egg weight (g) at 28 weeks of age (EW_{28}) was found to be 50.55 ± 0.23, 50.22 ± 0.23 and 51.20 ± 0.23 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. The EW_{28} was significantly ($P<0.05$) higher in RIR x IWP crossbred as compared to A x IWP and Na x IWP crossbreds.

The TEM_{40} was significantly ($P<0.05$) higher for Na x IWP and RIR x IWP crossbreds as compared to A x IWP crossbred.

Mean total feed consumption (kg/bird) for 21-40 weeks period (TFC_{40}) was found to be 15.529 ± 0.019, 15.405 ± 0.028 and 15.231 ± 0.019 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. The TFC_{40} was not differed significantly among the crossbreds.

Mean feed consumption per egg during 21-40 weeks (FC/E_{21-40}) was found to be 166.81 ± 2.83, 152.96 ± 2.26 and 153.71 ± 2.34 (g) in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. The FC/E_{21-40} was significantly ($P<0.05$) higher in A x IWP crossbred as compared to Na x IWP and RIR x IWP crossbreds.

Mean feed consumption per dozen eggs for 21-40 weeks period (FC/DE_{21-40}) was found to be 1.93 ± 0.02, 1.78 ± 0.02 and 1.79 ± 0.01 (kg) in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. The FC/DE_{21-40} was significantly ($P<0.05$) higher in A x IWP crossbred as compared to Na x IWP and RIR x IWP crossbreds.

Mean feed consumption per kilo eggs during 21-40 weeks (FC/KE_{21-40}) was found to be 3.18 ± 0.04, 2.94 ± 0.03 and 2.93 ± 0.04 (kg) in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. The FC/KE_{21-40} was significantly ($P<0.05$) higher in A x IWP crossbred as compared to Na x IWP and RIR x IWP crossbreds.

Mean Haugh unit (HU) was found to be 69.30 ± 2.08, 64.8 ± 1.62, 60.82 ± 2.20 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. The Haugh unit was significantly ($P<0.05$) higher in A x IWP crossbred as compared to RIR x IWP crossbred. The crossbreds did not differ significantly for Mean Albumin index, Yolk index, Yolk color and Shell thickness.

All three crossbreds had excellent livability during the experimental period. Livability (%) during 0-40 weeks period was found to be 97.2, 96.4 and 96 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively.

Return over feed cost (ROFC Rs./egg) was found to be 0.14 ± 0.04, 0.29 ± 0.03 and 0.28 ± 0.03 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. The ROFC was significantly ($P<0.05$) higher in Na x IWP and RIR x IWP crossbreds as compared to A x IWP crossbred.

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CERTIFICATE

This is to certify that the thesis entitled **"STUDIES ON COMPARATIVE PERFORMANCE OF THREE CROSSBRED CHICKENS SUITABLE FOR RURAL FARMING"** submitted by Podchalwar Kundan Suresh (Reg. No. 04-1116-2009) in partial fulfillment of the requirements for the award of the degree of **MASTER OF VETERINARY SCIENCE** in the subject of **POULTRY SCIENCE** of Anand Agricultural University is a record of bonafide research work carried out by him under my guidance and supervision and the thesis has not previously formed the basis for award of any degree, diploma or other similar title.

Place: Anand

Date:16/9/2011

Savalia

(F. P. SAVALIYA)

MAJOR ADVISOR

CERTIFICATE

This is to certify that I have no objection for supplying copy of any part of this thesis at a time through reprographic process, if necessary for rendering reference services in a library or documentation centre.

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DECLARATION

This is to declare that the whole of the research work reported in this thesis for partial fulfillment of the requirement for the degree of " **MASTER OF VETERINARY SCIENCE**" in **POULTRY SCIENCE** by the undersigned is the result of investigations done by me under direct guidance of **Dr. F. P. SAVALIYA**, Principal Scientist and Head, Department of Poultry Science, College of Veterinary Science and Animal Husbandry, Anand Agricultural University, Anand, and that no part of the work has been submitted for any other degree so far.

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Place : Anand

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(Podchalwar Kundan Suresh)

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ABBREVIATIONS USED

A	Australorp
AFE	Age at first egg
AS	Assel
ASM	Age at sexual maturity
BW_0	Body weight at day old
BW_{12}	Body weight at 12 weeks
BW_{16}	Body weight at 16 weeks
BW_{18}	Body weight at 18 weeks
BW_{20}	Body weight at 20 weeks
BW_{24}	Body weight at 24 weeks
BW_{28}	Body weight at 28 weeks
BW_{32}	Body weight at 32 weeks
BW_{36}	Body weight at 36 weeks
BW_4	Body weight at 4 weeks
BW_{40}	Body weight at 40 weeks
BW_8	Body weight at 8 weeks
C D	Critical difference
d	Days
DD	Deshi dwarf
DFC_{21-24}	Daily feed consumption from 21 to 24 weeks
DFC_{21-40}	Daily feed consumption from 21 to 40 weeks
DFC_{25-28}	Daily feed consumption from 25 to 28 weeks
DFC_{29-32}	Daily feed consumption from 29 to 32 weeks
DFC_{33-36}	Daily feed consumption from 33 to 36 weeks
DFC_{37-40}	Daily feed consumption from 37 to 40 weeks
DN	Deshi normal
EN_{24}	Egg number from 21 to 24 weeks
EN_{28}	Egg number from 25 to 28 weeks
EN_{32}	Egg number from 29 to 32 weeks
EN_{36}	Egg number from 33 to 36 weeks
EN_{40}	Egg number from 37 to 40 weeks
EW_{24}	Egg weight at 24 weeks
EW_{28}	Egg weight at 28 weeks
EW_{32}	Egg weight at 32 weeks
EW_{36}	Egg weight at 36 weeks
EW_{40}	Egg weight at 40 weeks

F	Frizzle
FC	Feed consumption
FC/DE$_{21-24}$	Feed consumption per dozen egg during 21-24 weeks
FC/DE$_{21-40}$	Feed consumption per dozen egg during 21-40 weeks
FC/DE$_{25-28}$	Feed consumption per dozen egg during 25-28 weeks
FC/DE$_{29-32}$	Feed consumption per dozen egg during 29-32 weeks
FC/DE$_{33-36}$	Feed consumption per dozen egg during 33-36 weeks
FC/DE$_{37-40}$	Feed consumption per dozen egg during 37-40 weeks
FC/E	Feed consumption per egg
FC/KE$_{21-24}$	Feed consumption per kilo egg during 21-24 weeks
FC/KE$_{21-40}$	Feed consumption per kilo egg during 21-40 weeks
FC/KE$_{25-28}$	Feed consumption per kilo egg during 25-28 weeks
FC/KE$_{29-32}$	Feed consumption per kilo egg during 29-32 weeks
FC/KE$_{33-36}$	Feed consumption per kilo egg during 33-36 weeks
FC/KE$_{37-40}$	Feed consumption per kilo egg during 37-40 weeks
Fcost	Feed cost
FES	Fertile eggs set
HD	Hen day
HDEP	Hen day egg production
HH	Hen housed
HHEP	Hen house egg production
i.e.	id est. (that is to say)
K	Kadakanath
M S	Mean sum of squares
Na NN	Naked neck
NH	New Hampshire
No	Number
RIR	Rhode Island Red
ROFC	Return over feed cost
SDL	Synthetic dam line
SE	Standard error
TEM40	Total egg mass from upto 40 weeks
TEN40	Total egg number upto 40 week
TES	Total egg set
TFC	Total feed consumption
TFC$_{40}$	Total feed consumption upto 40 weeks
viz.	Videlicet (namely)
wk	Week
WLH	White Leghorn

INTRODUCTION

CHAPTER I INTRODUCTION

Indian poultry industry is the fastest growing enterprise in the agriculture sector. It is growing at the rate of 6-8 % per annum in case of egg production and 12-15 % per annum for broiler meat production (Mehta and Nambiar, 2005). The contributing factors for this faster growth rate are continuous increase in demand of poultry products, improved genetic potential of the birds due to continuous and accurate selection and breeding strategies, improvement in managemental practices as well as health cover and availability of the quality balanced feed (Mohapatra and Misra, 2008). Indian poultry industry is better organized and is progressing towards modernization. The relative share of poultry in the national economy has remained below 1 percent, but its share in the livestock sector is continuously rising. The total value of poultry is 162 billion rupees in 2005-06 which accounted for 10.5% of the total value of livestock. India ranks 3th in egg production and 5th in meat production in world. Present per capita eggs and meat availability is 42 eggs and 1.76 kg meat per year respectively, as against the recommendation of National Institute of Nutrition (NIN) is 180 eggs and 11 kg meat annually (FAO, 2008). In India, comprehensive growth has been achieved in commercial poultry farming while the rural areas which held potential for small scale poultry farming and backyard poultry farming were largely kept out of this growth process. This happened despite the fact that rural backyard poultry is a major part of the activity portfolio of the majority of rural households. It contributes nearly 30% of the national egg production and improves household food security and income (Singh and Mishra, 2008).

In a developing country like India, rural poultry production is of great importance as it can provide supplementary income and nutritional security to rural people at very low input costs. Rural poultry farming fulfill a wide range of functions like the provision of meat and eggs, food for special festivals, chicken for traditional ceremonies, pest control and petty cash, utilizing minimum inputs, minimum human attention, and with less environmental pollution. Additionally, chicken meat consumption being a significant protein source, its consumption helps to cover the nutritional needs of the rural population (Mandal *et al.,* 2006). Therefore, it is essential to encourage rural poultry farming so as to provide the local population with high quality protein and supplementary income.

Local varieties adopted to climatic condition do not poor in productivity due to brooding behavior and exotic varieties line which is good at productivity but do not prime in harsh climate. Hence efforts are made to develop crossbreds which have desirable qualities of both the parents. For sustainable poultry production it is necessary to develop indigenous, appropriate, affordable and suitable breeding strategies for development of native birds so as to improve the efficiency of small-scale production especially in rural areas.

The need for development of varieties suitable for backyard production in India was visualized by poultry breeders during eighties. Giriraja variety developed by Project Directorate of Poultry, Hyderabad. Central Avian Research Institute, Izatnagar developed CARI – Nirbeek, CARI – Shyam, UPCARI, HITCARI to incorporate all desirable traits of native breeds in new genotypes (Viroji Rao and Chinni Preetam, 2009).

Various breeds of poultry possess characteristics which are suitable for rural or backyard poultry farming. We should exploit such characteristics to produce the breeds or strains of poultry suitable for rural farming. The crossbreeding is one such approach to fulfill this goal. The main purpose of crossing in chicken is to produce superior crosses utilizing hybrid vigor or complementarity to improve fitness and fertility traits and to combine different characteristics (Hanafi and Iraqi, 2001; Van Vleck, 1993). The exploitation of genetically diverse stocks for improving economic traits, such growth and reproductive traits are one of the approaches in poultry breeding programmes.

In present study males of Australorp (A), Naked neck (Na), and Rhode Island Red (RIR) has been used with female of White Leghorn (IWP strain) to produce crossbreds. Thus, present study has been designed to compare and evaluate performance of three crossbreds by mating of males of Australorp (A), Naked neck (Na), and Rhode Island Red (RIR) with the females of White Leghorn (IWP strain) with following objectives:-

Objectives:

1) To study the growth performance and sexual maturity of three crossbreds.
2) To study the egg production performance of three crossbreds up to 40 weeks of age.
3) To study the feed consumption and related feed efficiency traits.
4) To evaluate the fertility and hatchability percent of three crossbreds.
5) To study livability percent of crossbreds.
6) To study the economics of crossbreds.
7) To compare performance

REVIEW OF LITERATURE

CHAPTER II REVIEW OF LITERATURE

Crossbreeding and upgrading involving indigenous chicken using standard exotic breeds has been recommended to improve the quality of stocks suitable for rural condition (FAO, 1987). Crossbreeding is one of the tools for exploiting genetic variation. The main purpose of crossing in chicken is to produce superior crosses i.e. make use of hybrid vigor, to improve fitness and fertility traits and to combine different characteristics in which the crossed breeds were valuable (Hanafi and Iraqi, 2001).

Crossing of breeds improve egg production, egg size, viability, growth rate, body weight and adaptability of crossbreds under farm condition (Ali, 1989). The specific literature on crossbreds of present study is meager. However, available literature related to present study is reviewed below.

2.1 FERTILITY AND HATCHABILITY:

Fertility and hatchability have been reported to be influenced by genetic, physiological, social and environmental factors, male-female ratio, age, nutritional status, preferential mating, lighting, sperm quality, rate of production, quality of eggs etc. (Warren, 1953).

Trail (1961) observed higher fertility% (fertile eggs on eggs set) in crossbred progeny than in exotic parents. Crossbreeding improves hatchability by 5 to 20% in most crosses (Laxi, 1964). Bice and Tower (1939) observed higher hatchability in crossbred birds than in indigenous birds.

Ragob *et al.* (1957) reported that crossbreds of Fayoumi × RIR and Fayoumi × Light Sussex showed higher hatchability than Fayoumi.

Morris and Skaller (1958) reported that the reciprocal crosses of single crossing between White Leghorns and Australorps were consistently superior to the parental breeds (White Leghorn and Australorps) in hatchability.

The fertility and hatchability on FES was ranged from 47 to 78 % and 61 to 78 % in pure indigenous fowls and 63 to 83 % and 74 to 87 % in F1 crossbreds of indigenous with Dalhem Red respectively (Annonymus, 1996-97).

Rashid *et al.* (2005) studied the effect of dwarfism on reproductive and dressing parameters of crossbreds chicken. They selected twenty four indigenous autosomal dwarf hens and divided into 3 groups. They crossed indigenous hen with Rhode Island Red, White Leghorn and Fayoumi cocks i.e. Dwarf hen x Rhode Island Red, Dwarf hen x White Leghorn and Dwarf hen x Fayoumi cocks. They observed that fertility and hatchability on total and fertile egg basis of Dwarf hen x White Leghorn (95.57%, 68.74%, 72.41%) were higher (P<0.01) than Dwarf hen x Rhode Island Red (93.44%, 63.44%, 67.62%) and Dwarf hen x Fayoumi cocks (90.92%, 60.86%, 67.19%).

Reddy *et al.* (2005) studied certain economic characters and estimated of heritability in 3-way crossbred chicken flock developed by crossing Dahlem Red male line with 2-breed cross female line (RIR x WLH). The mean value of fertility was found 98.4 percent and hatchability of 95.1 and 96.7 percent was observed on total egg set and fertile egg set basis respectively.

Four breeding groups of Rhode Island Red (RIR) and White Leghorn (WLH) [RIR (♀) RIR (♂), RIR (♀) WLH (♂), WLH (♀) RIR (♂) and WLH (♀) WLH (♂)] were compared for fertility and hatchability by Zelleke *et al.* (2005). They observed that crossing of RIR (♀) with WLH (♂) resulted in an improvement (86.67%) as compared to pure RIR (76.67%) but it was lower than the pure WLH and WLH (♀) RIR (♂) crosses (97.12 and 97.72% respectively).

Sonawane *et al.* (2008) studied fertility and hatchability performance of eight different crossbreds verses purebreds. They found that percent fertility in crossbreds was highest in Coloured synthetic broiler x Frizzle (95.77%) and lower in Coloured synthetic broiler x Kadaknath (71.29%). The overall fertility in crossbreds was 84.24% and purebred was 86.13%. The percent hatchability on fertile egg set (FES) basis ranged from 81.39% (RIR x Colour synthetic broiler) to 95.79% (White Leghorn x Coloured synthetic broiler). The percent hatchability on total egg set basis (TES) basis ranged from 61.39% (RIR x Coloured synthetic broiler) to 88.23% (White Leghorn x Coloured synthetic broiler). The overall percent hatchability on FES and TES basis in crossbred was 87.61% and 74.81% respectively which was higher as compared to purebred (75.11 and 64.93 %) respectively. They concluded that crossbreeding has very little effect on fertility but hatchability on FES and TES basis improved in crossbreds as compared to purebreds.

The review on fertility of different genetic groups reported by different authors is presented below:

Table 2.1.1 Fertility for different genetic groups:

GENETIC GROUP	% FERTILITY	REFFERENCE
Fayoumi	89.00	Kicka *et al.* (1978)
RIR	77.90	
Deshi x WLH	71.13	Kumar and Acharya, (1975)
WLH x Deshi	85.61	
Desi x RIR	87.58	
RIR x Deshi	90.32	
Fayoumi x RIR	92.30	Kicka *et al.* (1978)
Aseel x Naked neck	73.45	Sakthivel, (1990)
Frizzle x Synthetic dam line (SDL)	81.74	

The review on hatchability of different genetic groups reported by different authors is presented below:

Table 2.1.2 Hatchability for different genetic groups:

GENETIC GROUP	% HATCHABILITY		REFFERENCE
	FES	TES	
Broiler	89.60	77.90	Ingram *et al.* (2007)
Fayoumi	-	85.70	Kicka *et al.* (1978)
RIR	-	66.80	
Fayoumi x RIR	-	72.20	
Kadaknath x Naked neck	73.08 (FES)	-	Sakthivel, (1990)
Aseel x Synthetic dam line	84.48 (FES)	-	
Aseel x Naked neck	49.56 (TES)	-	
Frizzle x Synthetic dam line	63.48 (TES)	-	

2.2 BODY WEIGHT:

Ragob *et al.* (1957) observed that progenies of Fayoumi × Light Sussex and Fayoumi × RIR were superior to pure Fayoumi, Light Sussex and RIR for body weight gain.

El-Maghraby *et al.* (1975) found that the cross with the highest average hatching weight was Fayoumi male x Rhode Island Red (RIR) female and the lowest was RIR male x Fayoumi female (37.5 and 29.0 g respectively). Birds of the Fayoumi male x RIR female cross and its reciprocal attained 316 and 299 g, the highest average 8th week body weight, respectively.

Menawat *et al.* (1977) reported that body weight of Desi and crossbred of White Leghorn (WLH) and RIR at 10th week were 675.5 g and 1006.42 g respectively.

The backcross of three way crossbred viz. Aseel peela (AP) x New Hampshire (NH) x Red and white Cornish breeds has shown that the progeny of three way cross grow faster than purebred (Annonyous, 1980).

Sah *et al.* (1984) compared crosses of Desi with WLH and their reciprocal under farm conditions and reported that higher 12 wk body weight in Desi x WLH (452.0 g) and its reciprocal cross WLH x Desi (378.0 g) as compared to their parents viz. Desi (321 g) and WLH (349.5 g) and suggested superiority of Desi bird as male line.

Islam (2004) found that RIR x Fayoumi crossbred had higher growth rate than their parents RIR and Fayoumi.

Phiri (2004) reported that the crossbred of Black Australorp and Hy-Line cross (BA x HY) responded highly in terms of growth and feed efficiency to the chick mash offered during the starter phase. The live body weight increased progressively in a linear fashion with the third, fourth and sixth week of age being significantly higher than BA.

Fayeye *et al.* (2005) evaluated the growth performance of Fulani-ecotype chicken which is the crossbred between indigenous fowls and RIR chicken. The body weight gain in Fulani-ecotype chickens increased from hatch to 3 weeks of age, and afterward declined.

Mohammed *et al.* (2005) formed different genetic groups by using RIR, Bovans (BO) and Egyptian Fayoumi (FO) males and large Baladi (LB), Bare-neck (BN) and Betwil (BT) females for the comparison of the average body weight up to 18^{th} week of age. They found the significant differences for average body weight of different crosses at hatching, 2, 14, 16 and 18 weeks of age.

Reddy *et al.* (2005) studied certain economic characters and ~~estimation of~~ heritability in 3 way crossbred chicken flock developed by crossing Dahlem Red male with 2 breed cross female line (RIR ♂ x WLH♀). They observed higher body weight

Singh and Jilani (2005) studied growth performance of Dahlem Red x Kadaknath crosses in both intensive and extensive system of poultry rearing. The weekly body weight in intensive system of rearing from 2nd to 8th weeks of age were 100.2 ± 0.96, 160.0 ± 1.90, 239.4 ± 2.10, 408.6 ± 2.80, 732.0 ± 3.63, 895.2 ± 4.20 and 996.2 ± 5.50 g respectively whereas corresponding body weights were 94.40 ± 0.98, 151.8 ± 1.96, 230.2 ± 2.34, 397.0 ± 2.92, 710.0 ± 3.82, 846.2 ± 4.60 and 931.2 ± 5.60 g in extensive system of rearing. At 16th week of age, body weight of extensive reared birds was slightly higher than intensive reared birds.

Nwachukwu *et al.* (2006) studied the effect on body weight in main and reciprocal crossbred of Normal local, Naked neck and Frizzle chicken with Exotic broiler breeder stock. They reported that Exotic x Normal local, Exotic x Nacked neck and Exotic x Frizzle chicken were lighter in body weight at sexual maturity (960.00, 812.50, 1030.00 g respectively) than their reciprocal crossbreds i.e. normal local x exotic, naked neck x exotic, frizzle x exotic (with body weight of 1891.67, 1576.50 and 2072.00 g respectively).

Sonawane (2007) studied the juvenile growth rate of eight different crossbreds for rural areas and reported that among the crossbreds RIRB (RIR as male line x Caribro as female line) performed better at day old, 2nd and 6th whereas BWLH (Broiler x White Leghorn) outperformed RIRB at 4th and 8th and BF had shown superior performance at 10th week of age. In females, BF (broiler x Frizzle) had highest body weight for 8th, 10th, 12th, and 14th week. It was observed that the genetic group had significant ($P<0.05$) effect at all ages. Among crossbreds the BF gained highest body weight at 5th, 6th, 7th, 8th, 9th, and 10th weeks. In males, BF had highest body weight gain for 3rd, 4th, 5th, 6th, 9th, and 10th weeks and RIRB had highest body weight gain for day old, 2nd, 7th and 8th weeks. In females, BF had highest body weight gain for 7th, 8th, 9th, 10th, 12th, 13th, and 14th while BRIR had highest body weight gain for 3rd, 4th, 5th and 6th and BWLH had highest weight gain for day old and 2nd weeks. In general, BF and RIRB had better weight gain as compared to other crossbreds.

The body weight of different genetic groups reported by different authors is presented below:

Table 2.2 Body weight for different genetic groups:

GENETIC GROUP	PERIOD	AVG. BODY WEIGHT (G)	REFERENCE
RIR	0 month	43.04	Saadey *et al.* (2008)
	1 month	237.89	
	2 month	958.08	
	3 month	1155.35	
	4 month	1288.88	
	5 month	1557.82	
AS x Na	0-day	47.24	Sakthivel (1990)
	2 week	166.29	
	4 week	452.54	
	5 week	633.19	
Native Chicken x RIR	16 week	1810	Cheenduang *et. al.*(2001)
Native Chicken x RIR x Barred Plymouth Rock		1600	
RIR x Fayoumi	23 week	1449	Rahman *et al.*(2004)
	30 week	1492	
	40 week	1666	
	50 week	1782	
	60 week	1846	
	70 week	1882.	
Fayoumi x RIR	23 week	1453	
	30 week	1511	
	40 week	1666	
	50 week	1829	
	60 week	1878	
	70 week	1897	

2.3 BODY WEIGHT AT SEXUAL MATURITY:

Huque (1999) studied the body weight differences at sexual maturity in scavenging system. They found lowest body weight in cross of Na x Fayoumi than that of Na x Na, Na x RIR, Na x WLH, RIR x RIR, WLH x WLH and Fayoumi x Fayoumi.

Zaman (2004) compared the crosses of RIR x Fayoumi, Na x Fayoumi and Na x RIR for body weight performance measured at the age of sexual maturity and bimonthly after that. The body weight was highest in RIR x Fayoumi (1325.9 g) crossbred whereas in contrast the lowest body weight was found in Na x Fayoumi (1033.7 g).

Nwachukwu *et al.* (2006) reported that Exotic broiler x Normal local, Exotic broiler x Nacked neck and Exotic broiler x Frizzle chicken were lighter in body weights at sexual maturity (960.00, 812.50, 1030.00 g respectively) than their reciprocal crossbreds i.e. Normal local x Exotic broiler, Naked neck x Exotic broiler, Frizzle x Exotic broiler (with body weight of 1891.67, 1576.50 and 2072.00 g respectively).

Chatterjee *et al.* (2007) studied direct and reciprocal crosses of Brown Nicobari and ILI 80 under the intensive and extensive management system. They observed that body weights at sexual maturity of the progeny of both direct and reciprocal crosses of Brown Nicobari with ILI-80 under intensive management was significantly higher (1192 and 1184 g respectively) than the progeny under backyard management system.

The body weight at sexual maturity of different genetic groups reported by different authors is presented below:

Table 2.3 Body weight at sexual maturity for different genetic group:

GENETIC GROUP	BODY WEIGHT (G)	REFERENCE
Fayoum	1170	Kicka *et al.*(1978)
RIR	1250	
	1320	Azizul and Reza, (1980)
Local	1010	
Fayoumi ×RIR	1290	Kicka *et al.* (1978)
RIR × Local	1216	Azizul and Reza, (1980)
RIR x CARI- BRO	3205.0 ± 11.05	Singh and Jilani, (2005)

2.4 AGE AT SEXUAL MATURITY:

It is an age when pullet laid her first egg. The differences in attaining sexual maturity might be due to breed differences.

Morris and Skaller (1958) reported decreased in the number of days required to reach sexual maturity for single cross of White Leghorn and Australorp as compared to Australorp.

Sazzad (1992) recorded age at sexual maturity of 155.5, 164 and 150 days for Fayoumi, RIR and Fayoumi x RIR respectively under farm condition.

Rahman *et al.* (1997) observed that age at sexual maturity of RIR x Fayoumi was 33rd weeks.

Zaman *et al.* (2004) studied the Fayoumi birds and three crossbreds for their egg production and reported that RIR x Fayoumi crossbreds attained late sexual maturity (222 days) as compared to Naked neck x Fayoumi and Naked neck x RIR.

Reddy *et al.* (2005) conducted an experiment in IWD and IWF strains of White Leghorn and 3 way breed cross (Delham Red male with F1 females(RIR x WLH)) and 2-way breed cross (F1xF1) to evaluate their production performance.

days and age at first egg was advanced by 5-8 days in 3 way cross over the other genetic groups.

Nwachukwu *et al.* (2006) reported that age of sexual maturity of Exotic broiler x Normal local, Exotic broiler x Nacked neck and Exotic broiler x Frizzle chicken was higher (170, 162 and 186 days, respectively) than their reciprocal crossbreds i.e. Normal local x Exotic broiler, Naked neck x Exotic broiler, Frizzle x Exotic broiler (158.33, 157 and 182.75 days, respectively).

Chatterjee *et al.*(2007) observed age at sexual maturity of the progeny of both direct and reciprocal crosses of Brown Nicobari with ILI-80 under intensive management was significantly lower (167 and 176 d) than the progeny of the same crosses under backyard management system.

The review of age at sexual maturity of different genetic groups reported by different authors is presented below:

Table 2.4 Age at sexual maturity of different genetic groups:

GENETIC GROUP	AGE	REFFERENCE
RIR	182.50 days	Yeasmin *et al.* (2003)
WLH	178.07 days	
	175.2 ± 7.6 days	Khalil *et al.* (2004)
Deshi Normal (DN)	169.00 days	Yeasmin *et al.*,(2003)
Deshi dwarf (DD)	170.60 days	
RIR × DN	181.80 days	
RIR × DD	174.00 days	
WLH × DN	185.11 days	
WLH × DD	178.90 days	
Fayoumi × DN	179.50 days	
Fayoumi × DD	187.75 days	
½ Baladi Saudi (S) X ½WLH	179.2 ±12.8 days	Khalil *et al.*, (2004)
½ WLH X ½ Baladi Saudi (S)	168.51± 2.7 days	
¾ Baladi Saudi (S)X ¼ WLH	157.5 ± 3.4 days	
¾ WLH X ¼ Baladi Saudi (S)	159.6 ± 3.4 days	
RIR x Fayoumi	147days	Rahman *et al.*, (2004)
Fayoumi x RIR	151days	
RIR x CARI-BRO	172.66±0.86days	Singh and Jilani, (2005)

2.5 EGG PRODUCTION:

A layer (Gramalakshmi) developed by Kerala Agricultural University which is a cross bred bird produced by crossing Australop male and F strain of White Leghorn female have the annual egg production about 180-200 eggs with light brown coloured eggs.

Morris and Skaller (1958) studied the single crossing between White Leghorn and Australorps and observed that both direct and reciprocal crosses were consistently superior to the parental breeds (White Leghorn and Australorp) in egg production.

Desai and Halbrook (1961) studied the egg production of various breeds of chicken under local conditions in Sudan. They observed that the White Leghorn breed lived and laid better than Brown Leghorn and Rhode Island Red with egg production over a 10 months period averaging 148, 107 and 108 for each breed, respectively.

Arad and Marder (1982) made comparison of the productive performance of the Sinai Bedouin fowl (from the Sinai desert), the commercial White Leghorn and their crossbreds which were reared under uniform normal conditions and found that crossbreeding of the Sinani improved productive performance and egg shell quality. .

Kassem *et al.* (1987) studied genotype x diet interaction in Fayoumi and Rhode Island Red and their crosses. They observed that the crossbred of Fayoumi male and RIR female produced significantly more eggs than the reverse cross (Sonali).

Mahopatra (1990) studied on local and imported fowl in India and observed that the egg production performance of synthetic strain was less than that of crossbreds of White Leghorn male x Deshi female and Rhode Island male x Deshi female.

Horst (1991) found improved egg production in crossbreds of D. Nana x Dahlem Red (German strain) and WLH x Kadaknath (Indian) chickens.

Khan (1998) used RIR and WLH for upgrading the native chickens and found that in third backcross generation egg production is increased by 70 and 64 eggs respectively.

Amber *et al.* (1999) observed that crosses of RIR x Fayoumi, Fayoumi x RIR, Fayoumi x WLH *and* RIR x WLH *resulted in early sexual maturity and higher* egg production.

Haque and Howlider (2001) showed better egg production in D. Nana x RIR under scavenging condition compare to exotic chickens.

Chatterjee *et al.* (2002) studied the direct and reciprocal crosses of Black and White Nicobari with WLH strain (ILI-80) and found increase production performance of Nicobari fowls under intensive and extensive management systems but with higher mortality under backyard. The annual egg production of pure Nicobari was much lower as compared to both the crosses under both the systems of management.

Rahman *et al.* (2004) compared the egg production performance of RIR x Fayoumi and Fayoumi x RIR crossbred chicken under intensive feeding and management system. Egg production improved 52.3% from the crossbred of Fayoumi x RIR compare with reciprocal cross.

Reddy *et al.* (2005) conducted an experiment in IWD and IWF strains of White Leghorn and 3 way breed cross (Delham Red male with F1 females (RIR x WLH)) and 2-way breed cross (F1xF1) to evaluate their production performance. They observed that genetic groups differ significantly for 280 days egg production and two White Leghorn pure strains had higher egg number of 114 eggs followed by 93 and 83 eggs in 2 way and 3 way breed crosses, respectively.

Nwachukwu *et al.* (2006) studied short term production and egg quality characteristics of main and reciprocal crossbred of Normal local, Nacked neck and Frizzle chicken x Exotic broiler breeder stock in a humid tropical environment up to 36 th week of age. They reported that frizzle individual in both crosses outperformed their normal feather and Nacked neck counterparts in body weight and most of the egg traits.

Chatterjee *et al.* (2007) studied the progeny of both direct and reciprocal crosses of Brown Nicobari with ILI-80 under intensive and backyard management. They observed first 100 day egg production of pure Nicobari was lower (47.1 ± 4.94) than both the crosses of Brown Nicobari with ILI-80 (55.2 ± 2.91 and 56.4 ± 2.86) under the cage system of rearing and under the backyard pure Nicobari was still lower (37.2 ± 1.0).

Saadey *et al.* (2008) performed diallel crossing of Rhode Island Red and White Leghorn. Crossing between WLH x RIR improved egg weight. However, crossing between RIR x WLH resulted in high and positive heterosis percentage (H %) for egg number (1.72%). The average number of eggs in first 105 days of laying was 73.94 eggs/hen for WLH x RIR hens, which gave the highest egg number.

Islam and Nishibori (2010) worked on crossbreds reared in scavenging, semi-intensive or intensive systems resulting in birds with good adaptability to tropical climate, highly resistant to disease and performing even better than pure exotic or indigenous chickens. They observed that crossbreds of D. Nana with RIR or Fayoumi produce more eggs than that of RIR and Fayoumi under scavenging conditions in a tropical climate.

The review of egg production (%) of different genetic groups reported by different authors is presented below:

Table 2.5.1 Egg production (%) for different genetic groups:

GENETIC GROUP	EGG PRODUCTION (%)		PERIOD	REFERENCE
	HH	HD		
D. Nana	-	26.84	Annual	Haque *et al.* (2001)
WLH x Fayoumi	-	61.63		
WLH x Australorp	-	53.12		
WLH x RIR	-	58.71		
RIR x WLH	-	55.85		
Fayoumi x D. Nana	-	41.00		
WLH	-	42.00	Annual	Miah *et al.* (2002)
RIR	-	43.33		
Fayoumi x WLH	-	50.66		
Fayoumi x RIR	-	.51.00		
RIR x DN	63.68	-	322 days	Yeasmin *et al.*(2003)
RIR x DD	61.31	-		
RIR x Fayoumi	-	48.20	Annual	Rahman *et al.* (2004)
Fayoumi x RIR	-	52.30		
RIR x Fayoumi	32.00	37.00	46 weeks	Zaman *et al.* (2004)
NN x Fayoumi	12.00	21.60		
NN x RIR	16.7	26.00		

The review of egg production (Nos.) of different genetic groups reported by different authors is presented below:

Table 2.5.2 Egg production (Nos.) for different genetic groups:

GENETIC GROUP	EGG NO.	PERIOD	REFERENCE
RIR	199	Annual	Gongrattananun *et al.*(1993)
	241	Annual	Leotarakul *et al.* (1997)
	66 ± 2.3	45 week	Nthimo, (2004)
Baladi Saudi	177.3 ± 5.1	Annual	Khalil,*et al.* (2004)
WLH	215.9 ± 4.4		
Kadaknath	93.6	20 –72 wk	Singh and Prasad, (2005)
Native Chicken	30-40	Annual	Ratanawaraha, (1997)
Native Chicken	92	Annual	Chotesangasa *et al.*(1994)
Commercial laying hen	243		
Creole ×1/2 RIR	106.8	Pullet year	Asiedu and Weever, (1993)
3/4 RIR ×1/4 Creole	130.7		
Local x Dahlem Red	233		Joseph, (1995)
Cameroon naked neck	142		
½ Baladi Saudi X ½WLH	191.3 ± 7.5	Annual	Khalil,*et al.* (2004)
½WLH X ½ Baladi Saudi	209.4 ± 7.1		
¾ Baladi Saudi X ¼WLH	204.6 ± 3.9		
¾WLH X ¼ Baladi Saudi	216.5 ± 4.1		
Kadaknath x CARI Red	205.9	20-72 week	Singh and Prasad, (2005)
CARI Red x Kadakanath	195.7		
RIR x CARI-BRO	122.87±0.38	40 week	Singh and Jilani, (2005)

2.6 EGG WEIGHT:

Adedokun and Sonaiya (2002) used Nigeria Indigenous chicken (NI) from two ecological zones (i.e. Fulani, Fu; Fulani dwarf, FuD from the Northern Guinea Savanna and Yoruba, Y, from the Derived Savanna) and the German Dahlem Red normal (DR) and Dahlem Red Dwarf (DRD) to produce four genetic groups DR x Fu, Fu x DR, DR x Y, and FuD x DRD. They found mean 280-day egg weights were 55.7, 36.8 and 42.9g respectively, for DR, NI and the crosses. The DR x Fu cross had a significantly higher ($P<0.05$) egg weight with mean egg weight of 46.1g.

Khan *et al.* (2004) studied the different genotypes of chicken in semi scavenging system. They observed lowest egg weight in Hilly x Fayoumi crossbreds.

Overall egg weights of different genotypes were 44.37±0.48, 42.35±0.29, 46.23±0.41 and 55.02±0.8 g for RIR x Hilly, Hilly x Fayoumi crossbreds, sonali and Nera respectively.

Zaman *et al.* (2005) studied a breed and three crossbreds (RIR x Fayoumi, Na x Fayoumi and Na x RIR) at different age under semi scavenging system of management. They found that egg weight was highest (41.87, 44.03, 44.7 and 46.97 g) for RIR x Fayoumi at sexual maturity, one, two and three months after sexual maturity.

Chatterjee *et al.* (2007) evaluated the egg weights of crosses of Brown Nicobari x ILI-80 and ILI-80 x Brown Nicobari under the intensive management and backyard system of management and compared with the purebreds. The result had shown that there was no significant difference in egg weight among the progeny under both the management systems but the egg weight of pure Nicobari was lower (44.7 ± 2.13 and 40.2 ± 0.5) than both the crosses under both the systems of management.

Nwachuku *et al.* (2006) studied the effect of main and reciprocal crossbreeding of Normal Local (NL), Naked neck (Na) and Frizzle (F) x Exotic broiler breeder stocks (E). They observed that among the reciprocal crosses F x E genetic group had higher egg weight (44.00±1.38 g) than egg weight of 42.53±2.68 and 41.89±0.88 g for Na x E and NL x E respectively.

Saadey *et al.* (2008) performed 4 x 4 diallel crossing of Rhode Island Red (RIR), White Leghorn (WLH), Fayoumi (F) and Sinai (S). They noticed that S x RIR had heaviest egg weight (45.66 g) as compare to other crosses. While F x WLH and F x RIR were lowest in egg weight (41.65 and 41.92 g respectively).

The review of egg weight of different genetic groups reported by different authors is presented below:

Table 2.6 Egg weight for different genetic groups:

GENETIC GROUP	PERIOD	EGG WEIGHT (G)	REFFERENCE
WLH	1st egg	38.59	Yeasmin *et al.*(2003)
	Average	44.86	
Deshi Normal (DN)	1st egg	29.76	
Deshi Dwarf (DD)		29.37	
RIR × DN		35.28	
RIR × DD		32.08	
WLH × DN		35.79	
WLH × DD		31.12	
Fayoumi × DN		32.03	
Fayoumi × DD		30.51	
Deshi Normal (DN)	Average	37.76	
Deshi Dwarf (DD)		37.10	
RIR × DN		43.77	
RIR × DD		40.45	
WLH × DN		40.28	
WLH × DD		40.88	
Fayoumi × DN		39.94	
Fayoumi × DD		38.36	
RIR x Fayoumi	Average	49.40	Rahman *et al.* (2004)
Fayoumi x RIR		48.70	
Delham Red x (RIR x WLH)	40 week	57	Reddy *et al.* (2005)
Delham Red x (RIR x WLH)	64 week	63	

2.7 FEED CONSUMPTION AND FEED EFFICIENCY:

An efficient utilization of feed is affected by so many factors viz. environmental conditions as well as genetics of bird itself. The feed conversion efficiency are affected by the rate of growth of birds, metabolizable energy content of the ration, nutrient adequacy of the ration, environmental temperature and health condition of the birds.

Lebdan *et al.* (1962) found feed utilization in crossbred chickens were superior to that of purebreds.

Hamid and Islam (1980) made the comparative study of the performance of different pure and crossbred chicken. Feed efficiency was significantly better (P<0.01) in birds of group B_3 (crossbred) in comparison to that of group B_2 (crossbred), B3 (crossbred) and B4 (100% White Leghorn) at 18th week of age. Feed efficiency was also higher (P<0.01) in birds of group B_5 (100% RIR) compared with that of group B_4 at 18th week of age.

Howlider and Ahmad (1982) found significantly higher feed intake in crossbreds of Aseel × Australorp (2816.5 g/ bird) than Australorp × New Hampshire (2637.5 g/ bird), with slightly efficient feed utilization in Australorp × New Hampshire cross (2.80 vs. 2.76) in 8 weeks of experimental period.

Wu and Han (1983) observed that age, sex of the bird and quality of diet significantly affected the feed efficiency.

Merat (1986) reported that Fayoumi had significantly poor feed conversion efficiency than RIR male x Fayoumi female up to 42 weeks.

Shivprasad *et al.* (1994) reported crossbred of RIR or WLH male with D. Nana female are heavier with lower FCR.

Sakthivel (1990) found highest feed efficiency value in AS x Na while lowest value was observed for K x Coloured Synthetic female line and he concluded that progenies of AS (male line) had overall better performance with respect to live weight and feed conversion ratio.

Massaddeq *et al.* (2002) studied the performance of RIR x Fayoumi. Four different rations were offered viz. commercial feeds, concentrate pack, cereal mixture and wheat bran. The laying and hatching performance of these birds were observed for two months of the conduct of experiment. The results indicated that the birds reared on commercial feed and concentrated pack based ration showed best egg production, feed conversion ratio and hatchability. The birds reared on rations based on cereal mixture and wheat bran had comparatively poor performance.

Islam (2004) reported crossbred birds of RIR × Fayoumi have got the superiority over their parents in all aspects including FCR.

The review of feed consumption of different genetic groups reported by different authors is presented below:

Table 2.7.1 Feed consumption for different genetic groups (g / bird / day):

GENETIC GROUP	AGE	FEED CONSUMED	REFFERENCE
RIR	20-24 week	68.96	Ali *et al.* (1993)
Fayoum		70.86	
RIR x Fayoumi		68.32	
D. Nana	16-17 week	58.31	Huque, (1999)
WLH		50.93	
D. Nana x RIR		58.54	
D. Nana x WLH		56.40	
WLH	20-24 week	58.06	Miah *et al.*(2002)
RIR		63.86	
Fayoumi x WLH		60.72	
Fayoumi x RIR		60.60	
RIR	322 days	96.07	Yeasmin *et al.* (2003)
WLH		92.71	
Fayoumi		93.55	
Deshi Normal (DN)		75.10	
Deshi Dwarf (DD)		57.81	
RIR × DN		84.67	
RIR × DD		75.53	
WLH × DN		78.91	
WLH × DD		70.11	
FO × DN		79.17	
FO × DD		67.21	
RIR x Fayoumi	19-70 week	96.0	Rahman *et al.* (2004)
Fayoumi x RIR		98.4	

Rashid *et al.* (2005) found improved feed conversion in crossbreds of autosomal dwarf hens with Rhode Island Red, White Leghorn and Fayoumi Cocks. The crossbred of autosomal dwarf hens and RIR had significantly less feed consumption and better feed conversion ratio (FCR) as compared to pure autosomal dwarf hens.

. Chatterjee *et al.* (2007) studied the direct and reciprocal crosses of Brown Nicobari and ILI-80 under the intensive management and backyard system of management. They found feed conversion efficiency (as measured by average feed consumption per dozen of eggs) were recorded only under intensive management system and there was no significant difference of these traits between Brown Nicobari x ILI-80 (2.44 ± 0.21) and ILI-80 x Brown Nicobari (2.41 ± 0.16).

The review of feed conversion ratio of different genetic groups reported by different authors is presented below:

Table 2.7.2 Feed conversion efficiency for different genetic groups:

GENETIC GRUOP	FEED CONVERSION EFFICIENCY		REFERENCE
	KG FEED/DZ EGG	KG FEED/KG EGG MASS	
RIR	-	6.39 ± 0.2	Kumar *et al.* (1976)
RIR x Deshi	-	11.20 ± 1.1	
Deshi x RIR	-	8.43± 0.5	
RIR x DN	-	3.08	Yeasmin *et al.* (2003)
RIR x DD	-	3.08	
WLH x DN	-	3.05	
WLH x DD	-	2.89	
Fayoumi x DN	-	3.08	
Fayoumi x DD	-	2.88	
ILI 80 x BrownNicobari	2.41 ± 0.16	-	Chatterjee *et al.* (2007)
Brown Nicobari x ILI 80	2.44 ± 0.21	-	

2.8 EGG QUALITY:

Haque *et al.* (2001) found that superior albumin index and Haugh unit in crosses between Nacked neck and Fayoumi than Nacked neck with RIR and White Leghorn.

Khan *et al.* (2004) studied the egg qualities of different genotypes of chicken Viz. Nera, Sonali, RIR x Hilly, Hilly x Fayoumi. They found that shell thickness of Nera was significantly higher (0.38 mm) than other three genotyps. There were no significant difference for shell thickness between RIR x Hilly, Hilly x Fayoumi and Sonali while yolk index of RIR x Hilly was lower (0.374±0.005) than other genotypes. Haugh unit of Nera was higher (86.20±1.84) than other genotypes. There were no differences for Haugh unit between RIR x Hilly, Hilly x Fayoumi and Sonali.

Zaman *et al.* (2004) reported that RIR x Fayoumi had highest Yolk colour fan score, Haugh unit and Shell thickness i.e. (9.8, 79.9 and 0.33 mm respectively) than Na x RIR and Na x Fayoumi.

Zaman *et al.* (2005) studied three crossbreds RIR x Fayoumy, Na x Fayoumi and Na x RIR, for egg quality traits at different age under semi scavenging system. They found that RIR x Fayoumi showed the highest shell thickness (0.335, 0.337 and 0.340 mm) and albumin height (7.77, 8.48 and 8.54 mm) at sexual maturity, one and three month after sexual maturity. The highest yolk color score (10.78) was in RIR x Fayoumi at sexual maturity and thereafter it declined.

Chatterjee *et al.* (2007) studied the direct and reciprocal crosses of Brown Nicobari and ILI-80 under the intensive management and backyard system of management. They found that significant ($P<0.05$) difference of shape index, albumen weight, yolk weight, yolk height, shell weight between the progeny of direct and reciprocal crosses of Brown Nicobari with ILI-80.

2.9 LIVABILITY:

Most of crossbreds had higher livability than purebreds (Iraqi *et al.* 2005). Hutt (1938) reported a lower mortality in upgraded birds compared to indigenous stock of improved birds.

Morris and Skaller (1958) found that the reciprocal crosses of single crossing between White Leghorns and Australorps were consistently superior to the better of the parental breeds (White Leghorn and Australorps) in chick viability. But crossbreeding was not effective in improving the viability of adult birds.

Chhabra and Sapra (1973) reported the mortality pattern from hatching to 4 weeks of age averaged 12.27 to 35.38 percent, respectively for the indigenous breeds, 8.32 to 8.49 percent for the exotic breeds and 13.34 to 10.80 percent for the crossbreeds.

Azizul and Reza (1980) observed 45.45% mortality for RIR, 13.63% for upgraded birds and 9.03% for native birds in Bangladesh.

Howlider and Ahmed (1982) observed better livability in Australorp × New Hampshire cross as compare to Aseel × Australorp. The percent of mortality recorded was 14.28 and 19.04 respectively.

Hossain *et al.* (1991) found lower mortality in crossbreds of Naked neck × Broiler (2.04 %) as compared to pure Broiler (6.00 %) under intensive conditions.

Amin *et al.* (1992) found that the mortality percentage of RIR male x Fayoumi female and desi were 50% and 29% respectively in semi scavenging condition.

Amber (1994) studied the production performance of 22 different genetic combinations of both native and exotic birds under intensive condition and found that mortality of RIR male x Fayoumi female, Desi male x Fayoumi female, Fayoumi male x Desi female and RIR male x Desi female were 14.6%, 15%, 20% and 13.1% respectively.

Sakthivel (1990) reported crossbreds of K x SDL (Synthetic dam line) had lowest (1.75%) while K x Na crossbreds shown highest (12.28%) mortality respectively upto 6th week of age.

Iraqi *et al.* (2005) compared the livability among the crossbreds of four breeds viz., Rhode Island Red (RIR), White Leghorn (WLH) Fayoumi (FA) and Dandarawi (DA). The highest livability was recorded in RIR × DA whereas as lowest in RIR × WLH crossbreds.

Singh *et al.* (2005) studied the Assel x Dahlem Red crosses in backyard condition and they reported that the survivability up to 20 weeks of age was 96.50%.

The review on livability of different genetic groups reported by different authors is presented below:

Table 2.9 Livability at different period for different genetic groups:

GENETIC GROUP	PERIOD	MORTALITY %	REFFERENCE
Naked neck x RIR	0-46 week	40.0	Zaman, (2004)
NN x Fayoumi		37.0	
RIR x Fayoumi		27.0	
Fayoumi		31.0	
RIR x Fayoumi	19-70 week	16.2	Rahman *et al.*(2004)
Fayoumi x RIR		13.4	
Aseel X Dahlem Red	0-20 week	3.50	Singh *et al.* (2005)
ILI-80 (WLH) X Brown Nicobari	Laying Period	5.82	Chatterjee *et al.* (2007)
Brown Nicobari X ILI-80 (WLH)		7.96	

2.10 ECONOMICS:

Amin *et al.* (1992) reported the highest net return from RIR x Fayoumi while the lowest benefit cost ratio from indigenous chicken in scavenging system. The difference of benefit cost ratio might be due to the system of production and the genotype.

Rahman *et al.* (1997) observed the higher productivity of Sonali as compared to RIR and Fayoumi under smallholder hill farming condition with feed supplementation.

Phiri (2004) reported higher gross margins in full and semi-scavenging systems for Black Australorp and Hy-Line cross (BA x HY) than BA.

Zaman *et al.* (2008) obtained result of cost-benefit analysis; it revealed that the crossbred Sonali (RIR x Fayoumi) had a tendency to give increased benefit with the decrease of levels of supplementary feed. But in the case of Naked neck x RIR, Naked neck x Fayoumi and pure Fayoumi increased benefit was obtained with lowest level of supplementary feed and it was the highest for Fayoumi. On the contrary, the benefit cost ratio was highest in RIR x Fayoumi, although it was high in all of the breeds with lowest level of supplementary feed.

Doley *et al.* (2009) compared the economy of production in indigenous chicken of North-Eastern region of India under intensive, semi-intensive and extensive systems and observed that rearing of indigenous chicken under extensive system was more profitable as compared to the other system.

MATERIALS AND METHODS

CHAPTER III MATERIALS AND METHODS

3.1 LOCATION:

The present research work was undertaken to evaluate and compare performance of three crossbreds by mating of males of Australorp (A), Naked neck (Na) and Rhode Island Red (RIR) with the White Leghorn females (IWP strain). The study was conducted at Department of Poultry Science, College of Veterinary Science and Animal Husbandry, Anand Agricultural University, Anand.

3.2 EXPERIMENTAL POPUALATION AND MATING PLAN:

The males of three different breeds viz. Australorp (A), Naked neck (Na) and Rhode Island Red (RIR) were mated to females of IWP strains of White Leghorn by means of artificial insemination to produce three different types of crossbred progeny i.e. A x IWP, Na x IWP and RIR x IWP which served as experimental material for present study. The experimental crosses have been designated as A x IWP, Na x IWP and RIR x IWP. The total 554, 543 and 521 chicks of A x IWP, Na x IWP and RIR x IWP respectively were generated. (Plate No. 3.3-3.5)

The mating plan for production of crossbred was as follows:

♀ \ ♂	Australorp (A)	Naked Neck (Na)	Rhode Island Red (RIR)
White Leghorn (IWP)	A x IWP	Na x IWP	RIR x IWP

3.3 MANAGEMENT OF THE EXPERIMENTAL STOCK:

The existing facilities of the Department of poultry Science, College of Veterinary Science and Animal Husbandry, Anand Agricultural University, Anand were utilized for the purpose of rearing and housing of the birds.

3.3.1 BROODING OF CHICKS:

The chicks were reared in Brooder-cum-grower houses having 10' x 10' rooms for brooding of the chicks. Brooder houses were thoroughly cleaned to remove all organic materials and disinfected. Equipments used for brooding of chicks were cleaned and washed thoroughly. Bajra husk used as litter material and was disinfected. Brooder houses were regularly disinfected at weekly interval.

After cleaning and disinfection of brooder houses and equipments proper arrangement of different equipments was made before placement of chicks. Three bulbs each of 100 watts capacity were fitted inside the hover-canopy brooders. These bulbs were sufficient to brood 250 chicks under the brooder. Bulbs were switch on 12 hours before the arrival of chicks in the brooder house. Temperature under the brooder was maintained at 95^{o} F in first week and subsequently it was reduced and adjusted as per the behavior of chicks under brooder. During first week 24 hours of the light were provided to chicks and then reduction of 1 hour per week i.e. total 23 light hours were provided for adaptation to dark hours. (Plate No. 3.1)

After 6 hours of placement of chicks under brooder, grinded maize was offered on the newspaper over the litter material for first day. Thereafter, starter mash was given to chicks in the linear chick feeders up to 4 weeks of age. After 4 weeks the bigger linear chick feeders were placed for feeding.

Every 3rd day of brooding news paper was replaced to maintain hygienic condition up to 10 days of brooding. Floor space was expanded by expanding the chick guards as age advanced. Litter material was stirred frequently to keep it dry.

3.3.2 GROWER MANAGEMENT:

Good performance during laying stage requires sound management of grower birds during 9 to 20 weeks of age. Grower birds were shifted from starter mash to grower mash gradually during the 8th week. As the age of birds advanced number, size and height of feeders and waterers were increased and also the floor space provided to birds was also increased. During the grower stage, birds were provided only day light and no extra light were provided. Frequent stirring of litter material was done to keep the litter material dry.

Birds were reared in same Brooder-cum-grower houses up to 16th weeks of age. 160 pullets each of A x IWP, Na x IWP and RIR x IWP crossbreds were transferred to individual layer cages in three tier California cage system during 17th weeks of age before they started to lay.

3.3.3 LAYER MANAGEMENT:

Layer birds were shifted gradually from grower mash to layer mash during 20th week in such a way that birds received layer mash completely from first day of 21st week. When flock reached to 5 percent egg production, artificial light was started. Light hours were increased by 30 minutes in equal halves in morning and evening every week and maximum 16 hours of total light hours were given including day light. (Plate No. 3.2)

Table 3.3.1 Feed formulation for crossbreds:

Sr. No.	Ingredient	Starter mash	Grower mash	Layer mash
		Rate of inclusion (kg)		
1	Maize	46.000	48.000	50.000
2	GNDOC	-	7.000	-
3	DRB	7.180	12.320	4.160
4	Rice polish	10.000	9.000	6.000
5	Mineral Mixer	0.200	2.500	2.500
6	Shell Grit	1.800	1.000	6.525
7	Soyabean	30.000	18.000	29.000
8	DCP	3.000	1.500	1.200
9	Salt	3.000	0.300	0.300
10	Vitamin B-Complex	0.010	0.010	0.010
11	Merivite (B12)	0.020	0.010	0.020
12	DL Methionine	0.125	-	-
13	Neftin	0.025	0.025	0.025
14	Lipocare	0.050	0.050	0.050
15	DOT	0.050	0.065	-
16	Rancimold	0.100	0.100	0.100
17	Lysine	0.050	0.060	-
18	Vitamins	0.010	0.010	0.010
19	$ZnSO_4$	-	-	-
20	$MnSO_4$	-	-	-
21	Zist	0.025	0.025	0.025
22	Liver Tonic	0.025	0.025	0.075
	Total	100.00	100.00	100.00
	Cost (Rs.) / 100 kg	1289.00	1128.00	1116.00

3.3.4 MEDICATION AND VACCINATION:

The birds were protected against deleterious diseases by medication and vaccination programme laid down at the farm as per as standard schedule. Other farm operations like debeaking, deworming were carried out under proper technical supervision and as per standard procedure.

Water soluble Cephalexin powder was given to the chicks in drinking water for first 5 days of brooding @ 5 g in 50 litre of water. Vitamin B Complex was also given in drinking water at regular interval @ 10 ml/100 chicks, 12 ml/100 grower birds and 16 ml/100 layer birds. Along with this, water soluble electrolyte powder was given @ 1g/2 litre of water.

3.3.4.1 VACCINATION PROGRAMME:

Name of Disease	Name of Vaccine	Age (days)	Dose (ml)	Route
Marek's Disease	HVT (bivalent strain)	Day old	0.2	S/C
Ranikhet Disease	F1 strain	7	0.1	I/O or I/N
Infectious Bursal Disesase (IBD)	Intermediate Georgia strain	14	0.03	Drinking water
Infectious Bursal Disesase (IBD)	Intermediate Georgia strain (Booster Dose)	21	0.03	Drinking water
Ranikhet Disease and Infectious Bronchitis	Lasota strain + IB	35	0.03	Drinking water
Fowl Pox	Chick embryo adopted strain of Fowl pox virus	49	0.2	I/M
Ranikhet Disease	Mukteshwar strain	69	0.5	I/M
Infectious Bronchitis (IB)	IB	84	0.3	Drinking water
Ranikhet Disease	ND killed	140	0.5	I/M

3.4 MEASUREMENT OF TRAITS:

3.4.1 FERTILITY AND HATCHABILITY TRAITS:

Percent fertility and hatchability were calculated separately for each crossbred using following formulas.

3.4.1.1 Fertility:

$$\text{Fertility (\%)} = \frac{\text{Number of fertile eggs}}{\text{Total number of eggs set}} \times 100$$

3.4.1.2 Hatchability:

Hatchability (%) was calculated on fertile egg set basis (FES) and on total egg set (TES) basis.

$$\text{Hatchability on FES (\%)} = \frac{\text{Number of chicks hatched}}{\text{Total number of fertile eggs set}} \times 100$$

$$\text{Hatchability on TES (\%)} = \frac{\text{Number of chicks Hatched}}{\text{Total number of eggs set}} \times 100$$

3.4.2 BODY WEIGHT (g):

Body weights (g) was recorded individually at day old to 40 weeks of age at 4 week interval in all crossbreds.

3.4.3 SEXUAL MATURITY TRAITS:

3.4.3.1 AGE AT 10 % PRODUCTION:

The age in days on which 10 percent production was attained in each of the crossbred flock.

3.4.3.2 AGE AT 50 % PRODUCTION:

The age in days on which 50 percent production was attained in each of the crossbred flock.

3.4.3.3 AVERAGE AGE AT FIRST EGG (AFE):

It is an age (days) when pullet laid her first egg. This was recorded for individual pullet and was averaged over each crossbred group.

3.4.4 EGG PRODUCTION TRAITS:

3.4.4.1 FLOCK EGG PRODUCTION:

A) Hen housed egg production % (HHEP %) :

$$\text{HHEP (\%)} = \frac{\text{Number of egg produced}}{\text{Number of birds housed X Number of Days}} \times 100$$

B) Hen day egg production % (HDEP %):

$$\text{HDEP (\%)} = \frac{\text{Number of egg produced during the period}}{\text{Number of birds during the period}} \times 100$$

3.4.4.2 INDIVIDUAL EGG PRODUCTION:

Egg number produced by each bird was recorded individually and was summed over four weekly and over the whole period of experiment.

3.4.5 EGG WEIGHT (g):

The egg weight (g) was recorded daily during whole experimental period. The average of four week i.e. at 24 (EW_{24}), 28 (EW_{28}), 32 (EW_{32}), 36 (EW_{36}) and 40 (EW_{40}) was considered for the present study.

3.4.6 EGG MASS:

Egg mass (kg) calculated up to 40 (TEM_{40}) weeks of age and was taken as a product of egg number and mean egg weight.

3.4.7 FEED CONSUMPTION:

The feed was given in replication basis (i.e. 8 replicates each of 20 birds in each crossbred groups during 21-40 weeks). The weighed quantity of feed was offered daily to each replicate of various crossbreds. The leftover was measured weekly interval and feed consumption of each replicate was calculated by substracting the left over from total feed given. Weekly feed consumption was summed over four week i.e. FC_{24}, FC_{28}, FC_{32}, FC_{36} and FC_{40} and total of 21-40 weeks i.e. TFC_{40} was considered for present study. For feed consumption and feed efficiency traits replicated data was used for analysis.

3.4.8 FEED EFFICIENCY:

Feed efficiency was measured as feed consumption per egg (FC/E), feed consumption per dozen eggs (FC/DE) and feed consumption per kg egg (FC/KE) over the period of experiment using following formulas.

3.4.8.1 Feed consumption per egg (FC/E):

$$FC/E = \frac{\text{Total feed consumed (kg) per replicate during the period}}{\text{Total number of eggs laid per replicate during the period}}$$

3.4.8.2 Feed consumption per dozen eggs (FC/DE):

$$FC/DE = \frac{\text{Total feed consumed (kg) per replicate during the period}}{\text{Total number of eggs laid per replicate during the period}} \times 12$$

3.4.8.3 Feed consumption per kg egg (FC/KE):

$$FC/KE = \frac{\text{Total feed consumed (kg) per replicate during the period}}{\text{Total egg mass produced (kg) per replicate during the period}}$$

3.4.9 EGG QUALITY TRAITS:

Egg quality traits were measured at 40 weeks of age on 15 pullets from each crossbreds group. Average three eggs per pullet were utilized for egg quality traits.

3.4.9.1 Albumen index:

$$\text{Albumen index} = \frac{\text{Maximum height of thick albumen (mm)}}{\text{Maximum width of thick albumen (mm)}}$$

3.4.9.2 Yolk index:

$$\text{Yolk index} = \frac{\text{Maximum height of the yolk (mm)}}{\text{Maximum width of yolk (mm)}}$$

3.4.9.3 Haugh unit (HU):

The height of thick albumen and egg weight were used for calculation of Haugh unit by using the following formula (Stadelman and Cotterill, 1973).

$$HU = 100 \log (H + 7.57 - 1.7 W^{0.37})$$

Where H = Height of thick albumen in mm

W = Egg weight in gram

3.4.9.4 Yolk colour:

The eggs were broken and the intensity of yolk colour was visually compared to the colour numbers in the 'Roche yolk colour fan' and corresponding yolk colour values were assigned.

3.4.9.5 Shell thickness:

The shell thickness was measured by using a micrometerscrew gauge with 0.01mm accuracy and the mean shell thickness was calculated.

3.4.10 LIVABILITY:

The percent livability was calculated on basis of number of birds remain alive after deducting mortality for each genetic groups during whole experimental period.

$$\text{Livability (\%)} = \frac{\text{Total number of birds alive}}{\text{Total number of birds housed}} \times 100$$

3.4.11 ECONOMICS:

Economics was calculated in terms of feed consumed per egg basis.

ROFC (Rs.) = Egg price – Fcost

Feed cost per egg (F_{cost}) = Feed consumption per egg (Kg) X Feed cost per kg (Rs.)
(Fcost) (Rs.)

5. Statistical Analysis:

The birds having complete information at 40 weeks of age were used for statistical analysis. The data on various traits recorded were analyzed using Completely Randomized Design (Snedecor and Cochran, 1980).

Feed consumption and feed efficiency traits were analyzed using replicated date while other traits were analyzed using individual data.

The structure of analysis of variance is given below.

ANOVA:

Source	df	Sum of square (SS)	Mean sum of square (MS)	Cal F
Treatment	t-1	SS_{TR}	MS_{TR}	MS_{TR}/MS_E
Error	n-t	SS_E	MS_E	-
Total	n-1	SS_{To}	-	-

t = Number of treatments   n = Total number of observations

Plate No. 3.1: Brooding of chicks

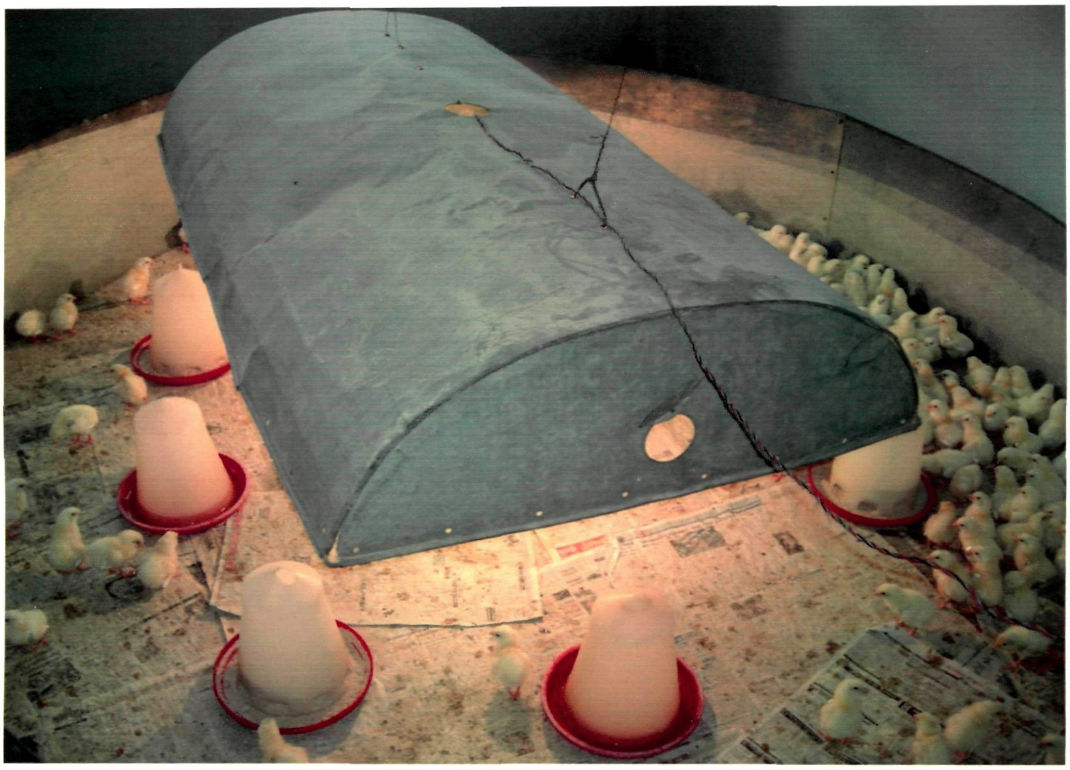


Plate No. 3.2: Layer House management

Plate No. 3.3:

A x IWP crossbred

Plate No. 3.4:

Na x IWP crossbred

Plate No. 3.5:

RIR x IWP crossbred

RESULTS AND DISCUSSION

CHAPTER IV RESULTS AND DISCUSSION

The present experiment was planned to compare and evaluate performance of three crossbreds which were generated by mating of males of Australorp (A), Naked neck (Na) and Rhode Island Red (RIR) with the females of White Leghorn (IWP strain) at Department of Poultry Science, College of Veterinary Science and Animal Husbandry, Anand Agricultural University, Anand.

Results of performance of three different crossbreds have been presented and discussed in this chapter under the following heads.

4.1 Fertility and Hatchability:

4.2 Body weight:

4.3 Sexual maturity traits:

4.4 Egg production traits:

4.5 Egg weight:

4.6 Egg mass:

4.7 Feed consumption:

4.8 Feed conversion efficiency:

4.9 Egg quality traits:

4.10 Livability:

4.11 Economics:

4.1 FERTILITY AND HATCHABILITY (%):

Results of the fertility and hatchability (%) have been presented in Table 4.1 and graphically depicted in Figure 4.1.

The percent fertility was found to be 97.83, 96.33 and 95.83 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. The percent hatchability on total egg set basis and fertile egg set basis was found to be 92.33, 90.50, 86.83 and 94.37, 93.94, 90.60 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. It was observed that A x IWP crossbred had better fertility as well as hatchability as compared to other crossbreds. The similar results of high fertility and hatchability percentage in crossbreds were also observed by Rashid *et al.* (2005); Reddy *et al.* (2005) and Zelleke *et al.* (2005) in RIR x Dwarf hen, Dahlem Red x (RIR x WLH) and RIR x WLH crossbreds.

Table 4.1: Fertility and hatchability (%):

Crossbreds	Fertility (%)	Hatchability (%)	
		TES	FES
A x IWP	97.83	92.33	94.37
Na x IWP	96.33	90.50	93.94
RIR x IWP	95.83	86.83	90.60

4.2 BODY WEIGHT (g):

The means along with standard errors for body weight (g) at different ages have been given in Table 4.2 and graphically depicted in Figure 4.2.

The mean body weight (g) at day old (BW_0) was found to be 32.31 ± 0.20, 33.01 ± 0.20 and 33.87 ± 0.20 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. The RIR x IWP crossbred has significantly ($P<0.05$) higher BW_0 followed by Na x IWP and RIR x IWP crossbreds.

Table 4.2: Mean body weight (g) of crossbreds at various ages:

TRAITS	CROSSBREDS			CD 5 %
	A x IWP	Na x IWP	RIR x IWP	
BW_0	32.31 ± 0.20^c	33.01 ± 0.20^b	33.87 ± 0.20^a	0.56
BW_4	196.44 ± 2.77^a	184.76 ± 2.74^b	195.91 ± 2.20^a	7.17
BW_8	572.60 ± 4.60^a	509.74 ± 5.39^b	512.88 ± 4.22^b	13.28
BW_{12}	990.02 ± 8.02^a	935.68 ± 7.11^b	943.86 ± 6.14^b	19.74
BW_{16}	1270.29 ± 9.20^a	1207.79 ± 7.05^b	1274.57 ± 6.15^a	20.86
BW_{20}	1627.56 ± 15.27^a	1441.78 ± 9.91^c	1562.87 ± 8.40^b	31.70
BW_{ASM}	1728.81 ± 14.44^a	1548.17 ± 10.66^c	1667.78 ± 8.88^b	31.79
BW_{24}	1892.97 ± 12.62^a	1662.40 ± 11.68^c	1775.72 ± 9.59^b	31.47
BW_{28}	1976.79 ± 13.64^a	1760.36 ± 13.35^c	1839.53 ± 12.36^b	36.41
BW_{32}	1886.11 ± 14.53^a	1703.71 ± 13.36^c	1748.07 ± 11.93^b	36.87
BW_{36}	1835.79 ± 15.78^a	1675.66 ± 14.08^b	1709.84 ± 12.95^b	39.61
BW_{40}	1790.72 ± 16.15^a	1678.35 ± 14.31^b	1651.14 ± 12.80^b	40.06

The mean body weight (g) at 4 weeks of age (BW_4) was found to be 196.44 ± 2.77, 184.76 ± 2.74 and 195.91 ± 2.20 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. The BW_4 was differd significantly ($P<0.05$) among the crossbreds. The A x IWP and RIR x IWP crossbreds have significantly ($P<0.05$) higher BW_4 as compared to Na x IWP crossbred but there was no significant difference in BW4 between A x IWP and RIR x IWP crossbreds.

The mean body weight (g) at 8 weeks of age (BW_8) was found to be 572.60 ± 4.60, 509.74 ± 5.39 and 512.88 ± 4.22 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. There were significant ($P<0.05$) differences in BW_8 among three crossbreds. The BW_8 was found to be significantly ($P<0.05$) higher in A x IWP as compared to other crossbreds but there was no significant difference in BW_8 between Na x IWP and RIR x IWP crossbreds.

The mean body weight (g) at 12 weeks of age (BW_{12}) was found to be 990.02 ± 8.02, 935.68 ± 7.11 and 943.86 ± 6.14 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. The BW_{12} in A x IWP crossbred was found significantly (P<0.05) higher as compared to other crossbreds and there was no significant difference in BW_{12} between Na x IWP and RIR x IWP crossbreds.

The mean body weight (g) at 16 weeks of age (BW_{16}) was found to be 1270.29 ± 9.20, 1207.79 ± 7.05 and 1274.57 ± 6.15 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. The BW_{16} was differed significantly (P<0.05) among the crossbreds. The A x IWP and RIR x IWP crossbreds have significantly (P<0.05) higher BW_{16} as compared to Na x IWP crossbred. However, there was no significant difference in BW_4 between A x IWP and RIR x IWP crossbreds.

The mean body weight (g) at 20 weeks of age (BW_{20}) was found to be 1627.56 ± 15.27, 1441.78 ± 9.91 and 1562.87 ± 8.40 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. There were significant (P<0.05) differences in BW_{20} among the crossbreds. The A x IWP crossbred has significantly (P<0.05) higher BW_{20} followed by RIR x IWP and Na x IWP crossbreds.

The body weight (g) at sexual maturity (BW_{ASM}) was found to be 1728.81 ± 14.44, 1548.17 ± 10.66 and 1667.78 ± 8.88 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. There were significant (P<0.05) differences in BW_{ASM} among the crossbreds. The A x IWP crossbred has significantly (P<0.05) higher BW_{ASM} followed by RIR x IWP and Na x IWP crossbreds.

The mean body weight (g) at 24 weeks of age (BW_{24}) was found to be 1892.97 ± 12.62, 1662.40 ± 11.68 and 1775.72 ± 9.59 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. The A x IWP crossbred has significantly ($P<0.05$) higher BW_{24} followed by RIR x IWP and Na x IWP crossbreds.

The mean body weight (g) at 28 weeks of age (BW_{28}) was found to be 1976.79 ± 13.64, 1760.36 ± 13.35 and 1839.53 ± 12.36 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. The A x IWP crossbred has significantly ($P<0.05$) higher BW_{28} followed by RIR x IWP and Na x IWP crossbreds.

The mean body weight (g) at 32 weeks of age (BW_{32}) was found to be 1886.11 ± 14.53, 1703.71 ± 13.36 and 1748.07 ± 11.93 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. The A x IWP crossbred has significantly ($P<0.05$) higher BW_{32} followed by RIR x IWP and Na x IWP crossbreds.

The mean body weight (g) at 36 weeks of age (BW_{36}) was found to be 1835.79 ± 15.78, 1675.66 ± 14.08 and 1709.84 ± 12.95 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. The BW_{36} in A x IWP crossbred was significantly ($P<0.05$) higher as compared to Na x IWP and RIR x IWP crossbreds but there was no significant difference in BW_{36} between Na x IWP and RIR x IWP crossbreds.

The mean body weight (g) at 40 weeks of age (BW_{40}) was found to be 1790.72 ± 16.15, 1678.35 ± 14.31 and 1651.14 ± 12.80 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. The BW_{40} in A x IWP crossbred was significantly ($P<0.05$) higher as compared to Na x IWP and RIR x IWP crossbreds but there was no significant difference in BW_{40} between Na x IWP and RIR x IWP crossbreds. The relevant references pertaining to body weight at particular age were not available in literature.

The highest body weights were observed in A x IWP crossbred at various ages. The present findings are in agreement with Sonawane, (2007) who observed highest body weight in BWLH (Broiler x White Leghorn). The lowest body weight at sexual maturity was observed in Na x IWP crossbred in the present study corresponds with the results of Zaman (2004) who observed lowest body weight at sexual maturity in Na x Fayoumi crossbreds. However contradictory result was observed by Nwachukwu *et al.* (2006) that showed lighter body weight at sexual maturity in Exotic broiler x Normal local crossbred.

During the experimental period body weight, egg production, egg weight and feed consumption were decreased after 32 weeks of age due to high environmental temperature.

4.3 SEXUAL MATURITY TRAITS:

The means along with standard errors for age at sexual maturity have been given in Table 4.3 and graphically depicted in Figure 4.3.

4.3.1. AGE AT 10% PRODUCTION:

The age at 10 % production was found to be 145, 142 and 142 days in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. The age at 10% production was found to be highest (145 days) in A x IWP crossbred and lowest (141days) in RIR x IWP crossbred.

4.3.2 AGE AT 50% PRODUCTION:

The age at 50 % production was found to be 167, 165 and 163 days in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. The age at 50 % production was

4.3.2 AGE AT 50% PRODUCTION:

The age at 50 % production was found to be 167, 165 and 163 days in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. The age at 50 % production was found to be higher (167 days) in A x IWP crossbred and lower (163 days) in RIR x IWP crossbred.

4.3.3 AVERAGE AGE AT FIRST EGG:

The average age at first egg in A x IWP, Na x IWP and RIR x IWP crossbreds was found to be 157.68 ± 0.65, 153.71 ± 0.36 and 153.56 ± 0.39 days, respectively. The average age at first egg was significantly ($P<0.05$) higher in A x IWP (157.68 ± 0.65 days) as compared to Na x IWP (153.71 ± 0.36 days) and RIR x IWP (153.56 ± 0.39 days) crossbreds. However, there was no significant difference in average age at first egg between Na x IWP and RIR x IWP crossbreds.

In the present findings age at sexual maturity was observed lower in RIR x IWP and Na x IWP crossbreds as compared to A x IWP crossbred. Finding similar to present study was observed by Rahman *et al.* (2004) and Reddy *et al.* (2005) in RIR x Fayoumi and Delham Red x (RIR x WLH) crossbreds. The contradictory result that showed age at sexual maturity was higher in RIR x Fayoumi crossbred observed by Rahman *et al.* (1997).

Table 4.3: Sexual maturity traits:

TRAITS	CROSSBREDS			CD 5%
	A x IWP	Na x IWP	RIR x IWP	
Age at 10% production (Days)	145	142	141	---
Age at 50% production (Days)	167	165	163	---
Average age at first egg (Days)	157.68±0.65^{a}	153.71±0.36^{b}	153.56±0.39^{b}	1.33

4.4 EGG PRODUCTION TRAITS:

4.4.1 EGG PRODUCTION (%):

The percent egg production on hen housed (HH) and hen day (HD) basis have been presented in Table 4.4.1.

The hen housed and hen day production percentage of all three crossbreds was calculated from 21st – 40th weeks. The hen housed production percent was found to be 65.70, 72.67 and 70.00 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. The hen housed egg production percent was found to be highest in Na x IWP followed RIR x IWP and A x IWP crossbreds.

The hen day production percent from 21st – 40th weeks was found to be 67.52, 73.45 and 71.32 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. The hen day egg production percent was found to be higher in Na x IWP followed by RIR x IWP and A x IWP crossbreds.

Table 4.4.1: Hen Housed (HH) and Hen Day (HD) egg production (%) of crossbreds at various ages:

AGE (week)	CROSSBREDS					
	A x IWP		Na x IWP		RIR x IWP	
	HH (%)	HD (%)	HH (%)	HD (%)	HH (%)	HD (%)
21-24	41.29	41.29	47.65	47.73	46.76	46.79
25-28	84.62	84.62	94.46	95.06	91.29	91.88
29-32	83.21	83.70	87.07	87.64	82.12	82.76
33-36	56.67	57.89	64.77	66.23	63.38	67.70
37-40	62.63	64.74	68.70	69.77	67.70	69.73
21-40	65.70	67.52	72.67	73.45	70.00	71.32

In present study the hen housed and hen day egg production (%) were observed higher in Na X IWP crossbred. Similar results were observed by Horst (1991) and Islam and Nishibori (2010) in D. Nana x Dahlem Red and D. Nana x Fayoumi crossbreds. However, on the contrary lower hen housed and hen day egg production (%) in Na x Fayoumi crossbreds was observed by Zaman *et al.* (2004).

4.4.2 EGG PRODUCTION (NO):

The means along with standard errors for egg number at four weekly intervals have been given in Table 4.4.2 and graphically depicted in Figure 4.4.2.

Mean egg production (No) at 24 weeks of age (EN_{24}) was found to be 10.29 ± 0.43, 12.12 ± 0.39 and 11.74 ± 0.39 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. The EN_{24} was differed significantly ($P<0.05$) among the crossbreds. The Na x IWP and RIR x IWP crossbreds have significantly ($P<0.05$) higher EN_{24} as compared to A x IWP crossbred. However, there was no significant difference in EN_{24} between Na x IWP and RIR x IWP crossbreds.

Mean egg production (No) at 28 weeks of age (EN_{28}) was found to be 24.46 ± 0.33, 26.62 ± 0.14 and 26.18 ± 0.18 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. There were significant ($P<0.05$) differences in EN_{28} among the crossbreds. The Na x IWP and RIR x IWP crossbreds have significantly ($P<0.05$) higher EN_{28} as compared to A x IWP crossbred. However, the EN_{28} was not differed significantly between Na x IWP and RIR x IWP crossbreds.

Mean egg production (No) at 32 weeks of age (EN_{32}) was found to be 24.63 ± 0.31, 24.84 ± 0.31 and 23.98 ± 0.43 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. There was no significant difference in EN_{32} between the crossbreds.

Mean egg production (No) at 36 weeks of age (EN_{36}) was found to be 17.09 ± 0.53, 19.05 ± 0.51 and 18.46 ± 0.55 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. The EN_{36} was differed significantly ($P<0.05$) among the crossbreds. The

EN_{36} was significantly (P<0.05) higher in Na x IWP crossbred as compared to A x IWP crossbred but was not significantly different from RIR x IWP crossbred.

Mean egg production (No) at 40 weeks of age (EN_{40}) was found to be 19.76 ± 0.53, 21.02 ± 0.49 and 21.49 ± 0.46 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. There were significant differences (P<0.05) in EN_{40} among the crossbreds. The EN_{40} was significantly (P<0.05) higher in RIR x IWP crossbred as compared to A x IWP crossbred but was not significantly different from Na x IWP crossbred.

Mean egg production (No) up to 40 weeks of age (TEN_{40}) was found to be 96.11 ± 1.28, 103.54 ± 1.26 and 101.86 ± 1.26 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. The TEN_{40} was differed significantly (P<0.05) among the crossbreds. The Na x IWP and RIR x IWP crossbreds have significantly (P<0.05) higher TEN_{40} as compared to A x IWP crossbred. However, there was no significant difference in TEN_{40} between Na x IWP and RIR x IWP crossbreds.

Table 4.4.2: Mean egg production (No) of crossbreds at various ages:

TRAITS	CROSSBREDS			CD 5%
	A x IWP	Na x IWP	RIR x IWP	
EN_{24}	10.29 ± 0.43^{b}	12.12 ± 0.39^{a}	11.74 ± 0.39^{a}	1.13
EN_{28}	24.46 ± 0.33^{b}	26.62 ± 0.14^{a}	26.18 ± 0.18^{a}	0.63
EN_{32}	24.63 ± 0.31	24.84 ± 0.31	23.98 ± 0.43	NS
EN_{36}	17.09 ± 0.53^{b}	19.05 ± 0.51^{a}	18.46 ± 0.55^{ab}	1.47
EN_{40}	19.76 ± 0.53^{b}	21.02 ± 0.49^{ab}	21.49 ± 0.46^{a}	1.38
TEN_{40}	96.11 ± 1.28^{b}	103.54 ± 1.26^{a}	101.86 ± 1.26^{a}	3.53

In the present findings higher egg production (No.) was observed in Na x IWP and RIR x IWP crossbreds. There was no significant difference in egg production between Na x IWP and RIR x IWP crossbreds. Similar results were reported by Amber *et al.* (1999); Haque and Howlider (2000) and Islam and Nishibori (2010) in RIR x WLH, D. Nana x RIR and D. Nana x Fayoumi crossbreds. However, on contrary lower egg production in RIR x Fayoumi crossbred was observed by Rahman *et al.* (2004).

4.5 EGG WEIGHT (g):

The means along with standard errors for egg weight at various ages have been given in Table 4.5 and graphically depicted in Figure 4.5.

Mean egg weight (g) at 24 weeks of age (EW_{24}) was found to be 46.40 ± 0.30, 45.73 ± 0.22 and 46.45 ± 0.23 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. The EW_{24} was not significantly different among the crossbreds.

Mean egg weight (g) at 28 weeks of age (EW_{28}) was found to be 50.55 ± 0.23, 50.22 ± 0.23 and 51.20 ± 0.23 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. There were significant ($P<0.05$) differences in EW_{28} among the crossbreds. The EW_{28} was significantly ($P<0.05$) higher in RIR x IWP crossbreds as compared to Na x IWP and A x IWP crossbreds. However, there was no significant difference in EW_{28} between Na x IWP and A x IWP crossbreds.

Mean egg weight (g) at 32 weeks of age (EW_{32}) was found to be 52.48 ± 0.21, 52.00 ± 0.18 and 52.66 ± 0.20 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. There was no significant difference in EW_{32} among the crossbreds.

Mean egg weight (g) at 36 weeks of age (EW_{36}) was found to be 50.59 ± 0.22, 50.67 ± 0.20 and 50.83 ± 0.22 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. The EW_{36} was not significantly different among the crossbreds.

Mean egg weight (g) at 40 weeks of age (EW_{40}) was found to be 50.54 ± 0.25, 51.27 ± 0.19 and 50.74 ± 0.22 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. The EW_{40} was not differed significantly among the crossbreds.

Egg weight was found to be significantly ($P<0.05$) higher in RIR x IWP crossbred as compared to A x IWP and Na x IWP crossbreds at 28 weeks of age while all egg weights at other ages were found to be non significant among the crossbreds.

Table 4.5: Mean egg weight (g) of crossbreds at various ages:

TRAITS	CROSSBREDS			CD 5%
	A x IWP	Na x IWP	RIR x IWP	
EW_{24}	46.40 ± 0.30	45.73 ± 0.22	46.45 ± 0.23	NS
EW_{28}	50.55 ± 0.23^{b}	50.22 ± 0.23^{b}	51.20 ± 0.23^{a}	0.65
EW_{32}	52.48 ± 0.21	52.00 ± 0.18	52.66 ± 0.20	NS
EW_{36}	50.59 ± 0.22	50.67 ± 0.20	50.83 ± 0.22	NS
EW_{40}	50.54 ± 0.25	51.27 ± 0.19	50.74 ± 0.22	NS

Chatterjee *et al.* (2007) was observed no significant difference in egg weight between Brown Nicobari x ILI-80 and ILI-80 x Brown Nicobari crossbreds. The highest egg weight was observed by Yeasmin *et al.* (2003) and Zaman *et al.* (2005) in RIR x DN and RIR x Fayoumi crossbreds.

4.6 EGG MASS (kg):

The means along with standard errors for egg mass up to 40 weeks of age have been given in Table 4.6 and graphically depicted in Figure 4.6.

Mean egg mass (kg) up to 40 weeks of age (TEM_{40}) was found to be 4.87 ± 0.06, 5.23 ± 0.06 and 5.19 ± 0.06 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. There were significant ($P<0.05$) differences in TEM_{40} among the crossbreds. The Na x IWP and RIR x IWP crossbreds have significantly ($P<0.05$) higher TEM_{40} as compared to A x IWP crossbred. However, there was no significant difference in TEM_{40} between Na x IWP and RIR x IWP crossbreds.

The literature pertaining to study of egg mass produced by crossbreds were meager. Deen *et al.* (2000) only reported increased egg mass production by crossbreeding.

Table 4.6: Mean egg mass (kg) of crossbreds up to 40 weeks of age:

TRAIT	CROSSBREDS			CD 5%
	A x IWP	Na x IWP	RIR x IWP	
TEM_{40}	4.87 ± 0.06^{b}	5.23 ± 0.06^{a}	5.19 ± 0.06^{a}	0.18

4.7 FEED CONSUMPTION:

The means along with standard errors for daily feed consumption (g/bird/day) at different ages have been presented in Table 4.7.

Mean daily feed consumption (g/bird/day) during 21-24 weeks of age (DFC_{21-24}) was found to be 123.25 ± 0.92, 120.00 ± 1.13 and 121.37 ± 0.94 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. There was no significant difference in DFC_{21-24} among the crossbreds.

Mean daily feed consumption (g/bird/day) during 25-28 weeks of age (DFC_{25-28}) was found to be 126.25 ± 0.99, 124.37 ± 1.56 and 124.75 ± 0.72 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. The DFC_{25-28} was not differed significantly among the crossbreds.

Mean daily feed consumption (g/bird/day) during 29-32 weeks of age (DFC_{29-32}) was found to be 124.50 ± 0.86, 122.50 ± 1.01 and 120.00 ± 1.51 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. The DFC_{29-32} was differed significantly ($P<0.05$) among the crossbreds. The A x IWP crossbred has significantly ($P<0.05$) higher DFC_{29-32} as compared to RIR x IWP crossbred. However, there was no significant difference in DFC_{29-32} between A x IWP and Na x IWP crossbreds.

Mean daily feed consumption (g/bird/day) during 33-36 weeks of age (DFC_{33-36}) was found to be 79.50 ± 1.18, 80.75 ± 0.97 and 79.00 ± 1.05 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. There was no significant difference in DFC_{33-36} among the crossbreds.

Mean daily feed consumption (g/bird/day) during 37-40 weeks of age (DFC_{37-40}) was found to be 100.87 ± 1.32, 101.87 ± 1.50 and 99.50 ± 0.98 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. The DFC_{37-40} was not differed significantly among the crossbreds.

Mean daily feed consumption (g/bird/day) during 21-40 weeks of age (DFC_{21-40}) was found to be 111.12 ± 0.63, 110.00 ± 0.92 and 108.62 ± 0.62 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. There was no significant difference in DFC_{21-40} among the crossbreds.

Mean total feed consumption (kg/bird) during 21-40 weeks of age (TFC_{40}) was found to be 15.529 ± 0.019, 15.405 ± 0.028 and 15.231 ± 0.019 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. The TFC_{40} was not differed significantly among the crossbreds.

In the present study non significant difference in feed consumption at different ages were observed among the crossbreds. In RIR x IWP crossbred significantly (P<0.05) lower feed consumption during 29-32 weeks of age. Similar finding was observed by Rahman *et al.* (2004) in RIR x Fayoumi crossbreds. However, on the contrary higher feed consumption was observed by Yeasmin *et al.* (2003) in RIR x DN crossbred.

Table 4.7: Mean feed consumption of crossbreds at different ages:

TRAIT	CROSSBREDS			CD 5%
	A x IWP	Na x IWP	RIR x IWP	
DFC_{21-24} (g)	123.25 ± 0.92	120.00 ± 1.13	121.37 ± 0.94	NS
DFC_{25-28} (g)	126.25 ± 0.99	124.37 ± 1.56	124.75 ± 0.72	NS
DFC_{29-32} (g)	124.50 ± 0.86^{a}	122.50 ± 1.01^{ab}	120.00 ± 1.51^{b}	3.42
DFC_{33-36} (g)	79.50 ± 1.18	80.75 ± 0.97	79.00 ± 1.05	NS
DFC_{37-40} (g)	100.87 ± 1.32	101.87 ± 1.50	99.50 ± 0.98	NS
DFC_{21-40} (g)	111.12 ± 0.63	110.00 ± 0.92	108.62 ± 0.62	NS
TFC_{40} (kg)	15.529 ± 0.019	15.405 ± 0.028	15.231 ± 0.019	NS

4.8 FEED EFFICIENCY:

4.8.1 FEED CONSUMPTION PER EGG (FC/E):

The means along with standard errors for feed efficiency in terms of feed consumption/egg (g/egg) from 21-40 weeks have been presented in Table 4.8 and graphically depicted in Figure 4.8.1.

Mean feed consumption per egg (FC/E_{21-40}) was found to be 166.81 ± 2.83, 152.96 ± 2.26 and 153.71 ± 2.34 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. The FC/E was differed significantly (P<0.05) among the crossbreds. The FC/E was significantly (P<0.05) higher in A x IWP crossbred as compared to Na x IWP and RIR x IWP crossbreds. However, there was no significant difference in FC/E between Na x IWP and RIR x IWP crossbreds.

4.8.2 FEED CONSUMPTION PER DOZEN EGGS (FC/DE):

The means along with standard errors for feed efficiency in terms of feed consumption/dozen egg (kg/ dozen eggs) have been presented in Table 4.8 and graphically depicted in Figure 4.8.2.

Mean feed consumption per dozen eggs during 21-24 weeks of age (FC/DE_{21-24}) was found to be 4.17 ± 0.30, 3.33 ± 0.06 and 3.59 ± 0.25 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively There was no significant difference in FC/DE_{21-24} among the crossbreds.

Mean feed consumption per dozen eggs during 25-28 weeks of age (FC/DE_{25-28}) was found to be 1.73 ± 0.03, 1.56 ± 0.01 and 1.60 ± 0.01 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. There were significant ($P<0.05$) differences in FC/DE_{25-28} among the crossbreds. The FC/DE_{25-28} was significantly ($P<0.05$) higher in A x IWP crossbred as compared to Na x IWP and RIR x IWP crossbreds. There was no significant difference in FC/DE_{25-28} between Na x IWP and RIR x IWP crossbreds.

Mean feed consumption per dozen eggs during 29-32 weeks of age (FC/DE_{29-32}) was found to be 1.70 ± 0.02, 1.66 ± 0.03 and 1.68 ± 0.01 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. The FC/DE_{29-32} was not differed significantly among the crossbreds.

Mean feed consumption per dozen eggs during 33-36 weeks of age (FC/DE_{33-36}) was found to be 1.56 ± 0.03, 1.43 ± 0.04 and 1.44 ± 0.03 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. There was no significant difference in FC/DE_{33-36} among the crossbreds.

Mean feed consumption per dozen eggs during 37-40 weeks of age (FC/DE_{37-40}) was found to be 1.71 ± 0.02, 1.64 ± 0.04 and 1.55 ± 0.02 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. There were significant ($P<0.05$) differences in FC/DE_{37-40} among the crossbreds. The FC/DE_{37-40} was significantly ($P<0.05$) higher in A x IWP crossbred followed by Na x IWP and RIR x IWP crossbreds.

Mean feed consumption per dozen eggs during 21-40 weeks of age (FC/DE_{21-40}) was found to be 1.93 ± 0.02, 1.78 ± 0.02 and 1.79 ± 0.01 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. The FC/DE_{21-40} was differed significantly ($P<0.05$) among the crossbreds. The FC/DE_{21-40} was significantly ($P<0.05$) higher in A x IWP crossbred as compared to Na x IWP and RIR x IWP crossbreds. There was no significant difference in FC/DE_{21-40} between Na x IWP and RIR x IWP crossbreds.

4.8.3 FEED CONSUMPTION PER KILOGRAM EGG (FC/KE):

The means along with standard errors for feed in terms of feed consumption/kilo egg (kg/kilo eggs) have been presented in Table 4.8 and graphically depicted in Figure 4.8.3.

Mean feed consumption per kilo eggs during 21-24 weeks of age (FC/KE_{21-24}) was found to be 7.15 ± 0.45, 5.81 ± 0.25 and 6.36 ± 0.45 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively There was no significant difference in FC/KE_{21-24} among the crossbreds.

Mean feed consumption per kilo eggs during 25-28 weeks of age (FC/KE_{25-28}) was found to be 2.85 ± 0.06, 2.60 ± 0.03 and 2.60 ± 0.03 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. The FC/KE_{25-28} was differed significantly ($P<0.05$) among the crossbreds. The FC/KE_{25-28} was significantly ($P<0.05$) higher in A x IWP crossbred as compared to Na x IWP and RIR x IWP crossbreds. The FC/KE_{25-28} was not differed significantly between Na x IWP and RIR x IWP crossbreds.

Mean feed consumption per kilo eggs during 29-32 weeks of age (FC/KE_{29-32}) was found to be 2.70 ± 0.05, 2.65 ± 0.05 and 2.65 ± 0.02 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. There was no significant difference in FC/KE_{29-32} among the crossbreds.

Mean feed consumption per kilo eggs during 33-36 weeks of age (FC/KE_{33-36}) was found to be 2.57 ± 0.06, 2.34 ± 0.06 and 2.36 ± 0.06 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. The FC/KE_{33-36} was differed significantly ($P<0.05$) among the crossbreds. The FC/KE_{33-36} was significantly ($P<0.05$) higher in A x IWP crossbred as compared to Na x IWP and RIR x IWP crossbreds. The FC/KE_{33-36} was not differed significantly between Na x IWP and RIR x IWP crossbreds.

Mean feed consumption per kilo eggs during 37-40 weeks of age (FC/KE_{37-40}) was found to be 2.82 ± 0.04, 2.66 ± 0.06 and 2.55 ± 0.04 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. There was significant ($P<0.05$) difference in FC/KE_{37-40} among the crossbreds. The FC/KE_{37-40} was significantly ($P<0.05$) higher in A x IWP crossbred than Na x IWP and RIR x IWP crossbreds. There was no significant difference in FC/KE_{37-40} between Na x IWP and RIR x IWP crossbreds.

Mean feed consumption per kilo eggs during 21-40 weeks of age (FC/KE_{21-40}) was found to be 3.18 ± 0.04, 2.94 ± 0.03 and 2.93 ± 0.04 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. The FC/KE_{21-40} was differed significantly ($P<0.05$) among the crossbreds. The FC/KE_{21-40} was significantly ($P<0.05$) higher in A x IWP crossbred than Na x IWP and RIR x IWP crossbreds. The FC/KE_{21-40} was not differed significantly between Na x IWP and RIR x IWP crossbreds.

Table 4.8: Feed efficiency of crossbreds:

TRAITS	CROSSBREDS			CD 5%
	A x IWP	Na x IWP	RIR x IWP	
FC/E_{21-40} (g)	166.81 ± 2.83^{a}	152.96 ± 2.26^{b}	153.71 ± 2.34^{b}	6.86
FC/DE_{21-24} (kg)	4.17 ± 0.30	3.33 ± 0.06	3.59 ± 0.25	NS
FC/DE_{25-28} (kg)	1.73 ± 0.03^{a}	1.56 ± 0.01^{b}	1.60 ± 0.01^{b}	0.06
FC/DE_{29-32} (kg)	1.70 ± 0.02	1.66 ± 0.03	1.68 ± 0.01	NS
FC/DE_{33-36} (kg)	1.56 ± 0.03	1.43 ± 0.04	1.44 ± 0.03	NS
FC/DE_{37-40} (kg)	1.71 ± 0.02^{a}	1.64 ± 0.04^{b}	1.55 ± 0.02^{c}	0.09
FC/DE_{2140} (kg)	1.93 ± 0.02^{a}	1.78 ± 0.02^{b}	1.79 ± 0.01^{b}	0.07
FC/KE_{21-24} (kg)	7.15 ± 0.45	5.81 ± 0.25	6.36 ± 0.45	NS
FC/KE_{25-28} (kg)	2.85 ± 0.06^{a}	2.60 ± 0.03^{b}	2.60 ± 0.03^{b}	0.13
FC/KE_{29-32} (kg)	2.70 ± 0.05	2.65 ± 0.05	2.65 ± 0.02	NS
FC/KE_{33-36} (kg)	2.57 ± 0.06^{a}	2.34 ± 0.06^{b}	2.36 ± 0.06^{b}	0.18
FC/KE_{37-40} (kg)	2.82 ± 0.04^{a}	2.66 ± 0.06^{b}	2.55 ± 0.04^{b}	0.15
FC/KE_{2140} (kg)	3.18 ± 0.04^{a}	2.94 ± 0.03^{b}	2.93 ± 0.04^{b}	0.11

In present study crossbreds of Na x IWP and RIR x IWP crossbreds had significantly ($P<0.05$) better feed efficiency as compared to A x IWP crossbred. Similar result was reported by Islam (2004) in RIR x Fayoumi crossbred. However, Chatterjee *et al.* (2007) have observed non significant difference in feed efficiency traits in Brown Nicobari x ILI-80 and ILI-80 x Brown Nicobari crossbreds.

4.9 EGG QUALITY TRAITS:

The means along with standard errors for various egg quality traits at 40 weeks of age have been given in Table 4.9.

Mean albumin index (AI) was found to be 0.05 ± 0.00, 0.05 ± 0.00 and 0.04 ± 0.00 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. There was no significant difference in albumin index among the crossbreds.

Mean yolk index (YI) was found to be 0.34 ± 0.00, 0.33 ± 0.00 and 0.35 ± 0.00 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. No significant difference was observed in yolk index among the crossbreds.

Mean Haugh unit (HU) was found to be 69.30 ± 2.08, 64.8 ± 1.62 and 60.82 ± 2.20 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. The Haugh unit differed significantly (P<0.05) among the crossbreds. The Haugh unit was significantly (P<0.05) higher in A x IWP crossbred as compared to RIR x IWP crossbred. However, there was no significant difference in Haugh unit between A x IWP and Na x IWP crossbreds.

Mean yolk color was found to be 3.13 ± 0.20, 2.57 ± 0.11 and 2.84 ± 0.13 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. The yolk color did not differ significantly among the crossbreds.

Mean shell thickness (mm) was found to be 0.35 ± 0.00, 0.35 ± 0.00 and 0.34 ± 0.00 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. There was no significant difference in shell thickness among the crossbreds.

In the present study A x IWP and Na x IWP crossbreds have significantly (P<0.05) better Haugh unit as compared to RIR x IWP crossbred while other egg quality traits were found to be non significant among the crossbreds.

Haque *et al.* (2001) was observed superior Haugh unit in Na x Fayoumi crossbred. However, on the contrary superior Haugh unit was observed by Zaman *et al.* (2004) in RIR x Fayoumi crossbred.

Table 4.9: Mean egg quality traits of crossbred at 40 weeks of age:

TRAITS	CROSSBREDS			CD 5%
	A x IWP	Na x IWP	RIR x IWP	
Albumin Index	0.05 ± 0.00	0.05 ± 0.00	0.04 ± 0.00	NS
Yolk Index	0.34 ± 0.00	0.33 ± 0.00	0.35 ± 0.00	NS
Haugh Unit	69.30 ± 2.08^{a}	64.8 ± 1.62^{ab}	60.82 ± 2.20^{b}	5.66
Yolk Colour	3.13 ± 0.20	2.57 ± 0.11	2.84 ± 0.13	NS
Shell thickness (mm)	0.35 ± 0.00	0.35 ± 0.00	0.34 ± 0.00	NS

4.10 LIVABILITY (%):

The livability (%) recorded at various interval has been presented in Table 4.10 and graphically presented in Figure 4.10.

The livability was divided into three phase i.e. brooding phase (0-8 weeks), growing phase (9-16 weeks) and laying phase (17-40 weeks). It was observed that all three crossbreds had excellent livability during the brooding, growing as well as laying phase. High livability similar to present study in crossbreds have been reported by Singh *et al.* (2005) in Assel x Dahlem Red and Chatterjee *et al.* (2007) in Brown Nicobari x ILI-80 and ILI-80 x Brown Nicobari crossbreds.

Table 4.10: Livability (%) of crossbreds at different ages:

AGE (week)	CROSSBREDS		
	A x IWP	Na x IWP	RIR x IWP
0-8	99.2	98.4	97.6
9-16	100	99.6	99.6
17-40	98	98.4	98.4
0-40	97.2	96.4	96

4.11 ECONOMICS:

The return over feed cost (Rs/egg) has been presented in Table 4.11 and graphically depicted in Figure 4.11.

Return over feed cost was calculated considering the price of Rs. 2.00/egg. Return over feed cost from 21-40 weeks of age ($ROFC_{21-40}$) was found to be 0.14 ± 0.04, 0.29 ± 0.03 and 0.28 ± 0.03 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. The ROFC was differed significantly ($P<0.05$) among the crossbreds. The ROFC was significantly ($P<0.05$) higher in Na x IWP and RIR x IWP crossbreds as compared to A x IWP crossbred. This was because of their better feed efficiency. However, there was no significant difference in ROFC between Na x IWP and RIR x IWP crossbreds. The differences in the ROFC were observed by Zaman *et al.* (2008) in RIR x Fayoumi, Naked neck x RIR and Naked x Fayoumi crossbreds.

Table 4.11: Return over feed cost (Rs/egg) of crossbreds:

TRAIT	CROSSBREDS			CD 5%
	A x IWP	Na x IWP	RIR x IWP	
ROFC	0.14 ± 0.04^{b}	0.29 ± 0.03^{a}	0.28 ± 0.03^{a}	0.09

Figure 4.1: Fertility and Hatchability (%)

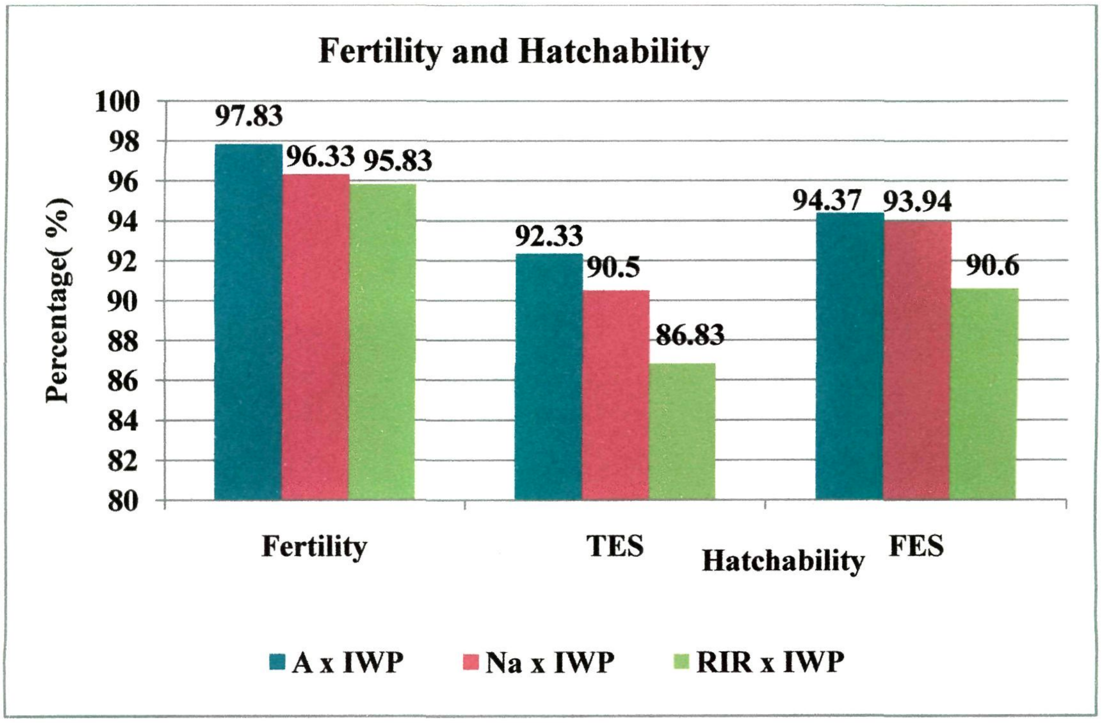
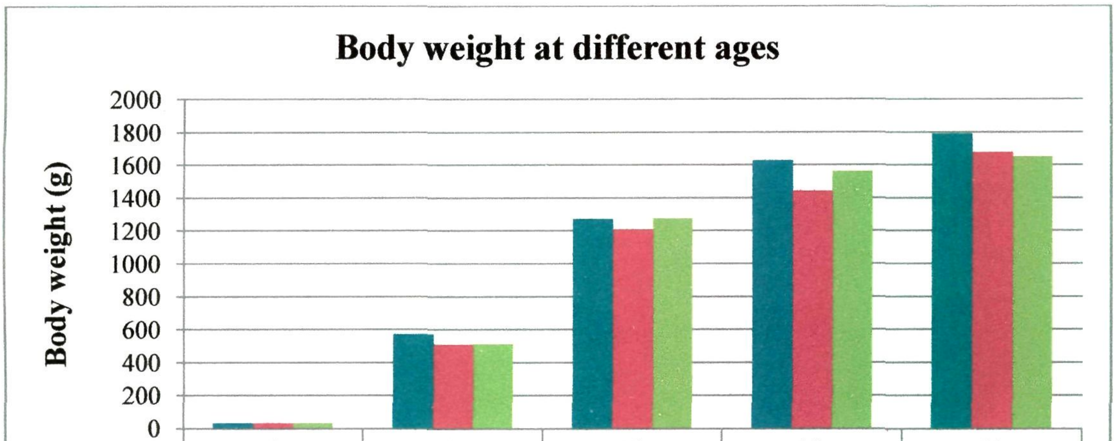


Figure 4.2: Mean body weight (g) at different ages



	0	8	16	20	40
A x IWP	32.31	572.6	1270.29	1627.56	1790.72
Na x IWP	33.01	509.74	1207.79	1441.78	1678.35
RIR x IWP	33.87	512.88	1274.57	1562.87	1651.14

Age in weeks

Figure 4.3: Sexual maturity traits

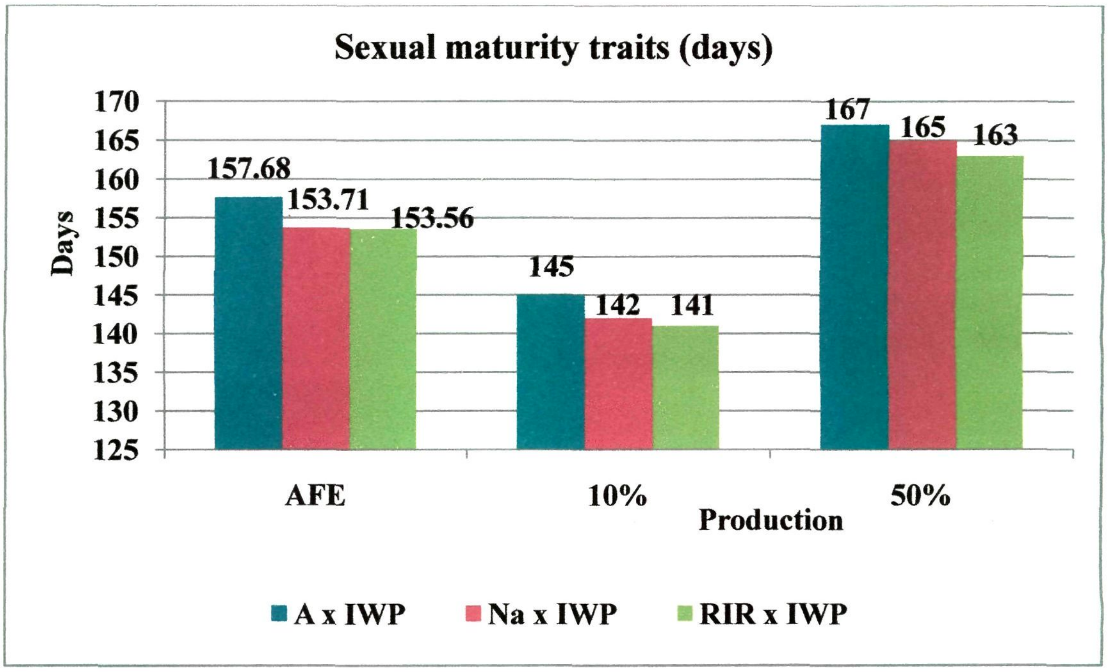
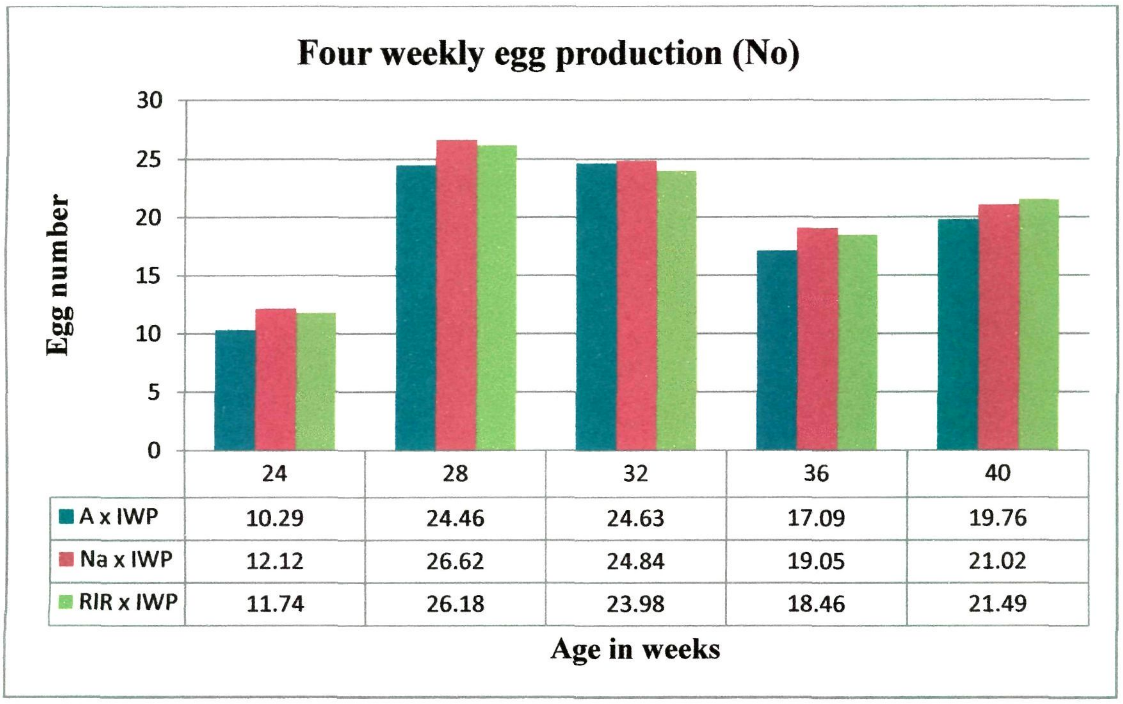


Figure 4.4.2 (a): Mean egg production (No) recorded at four weekly interval



	24	28	32	36	40
A x IWP	10.29	24.46	24.63	17.09	19.76
Na x IWP	12.12	26.62	24.84	19.05	21.02
RIR x IWP	11.74	26.18	23.98	18.46	21.49

Figure 4.4.2 (b): Egg production (No) up to 40 weeks of age (TEN_{40})

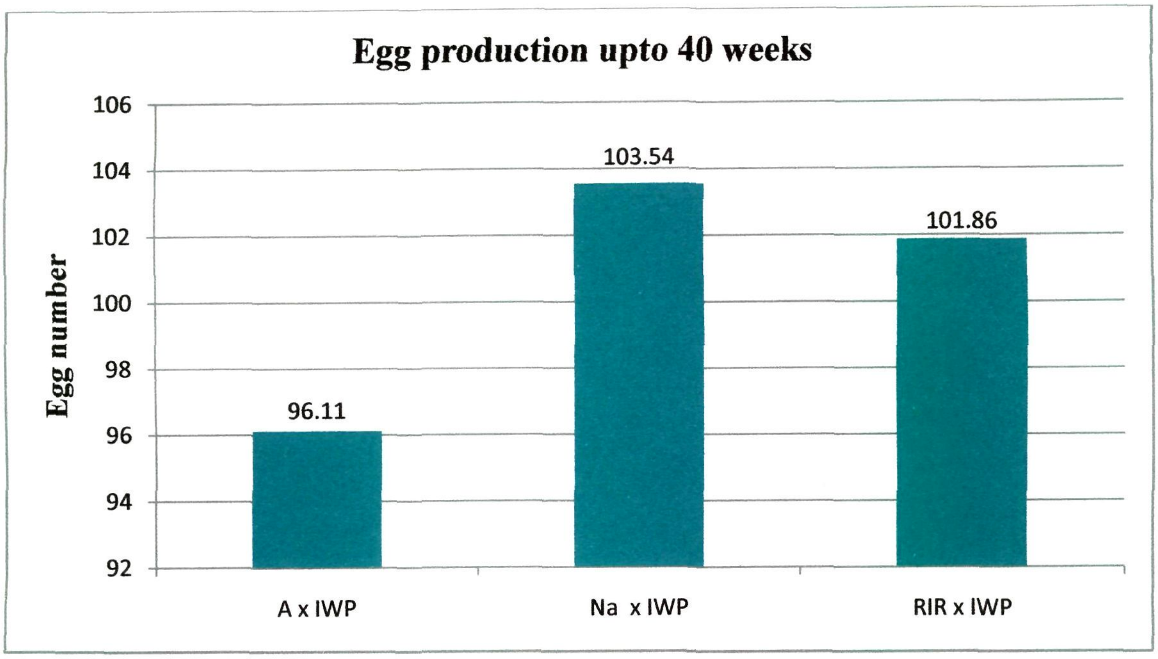
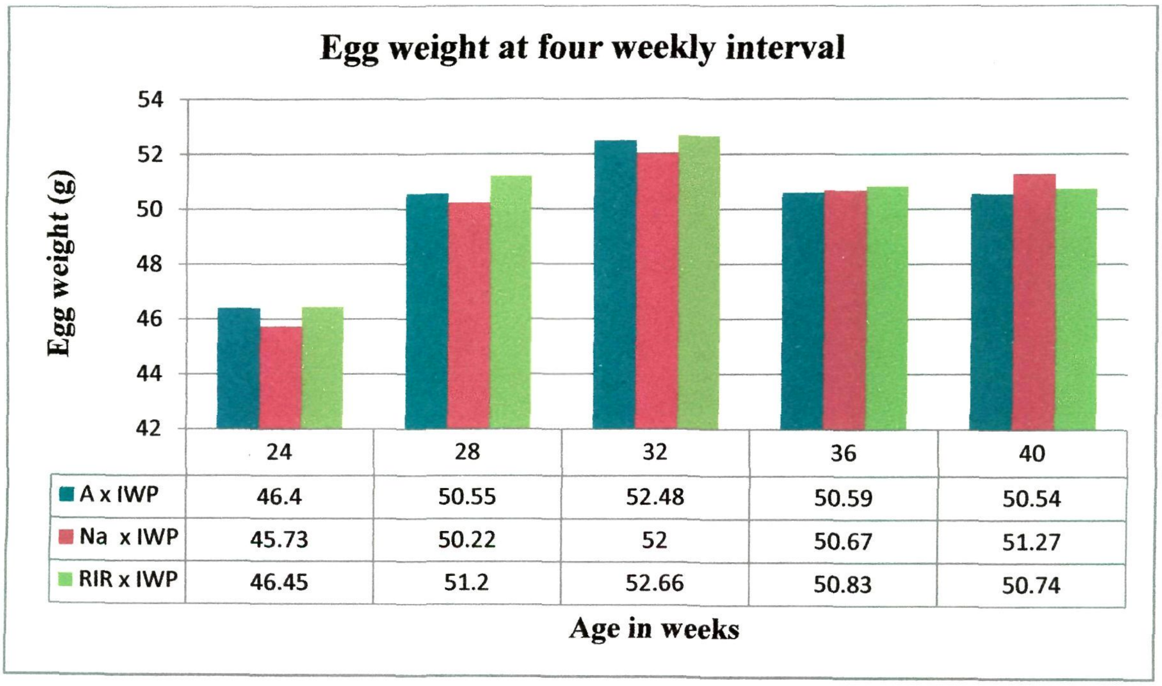


Figure 4.5: Mean egg weight (g) at four weekly interval



	24	28	32	36	40
A x IWP	46.4	50.55	52.48	50.59	50.54
Na x IWP	45.73	50.22	52	50.67	51.27
RIR x IWP	46.45	51.2	52.66	50.83	50.74

Figure 4.6: Mean egg mass (kg) up to 40 weeks of age (TEM_{40})

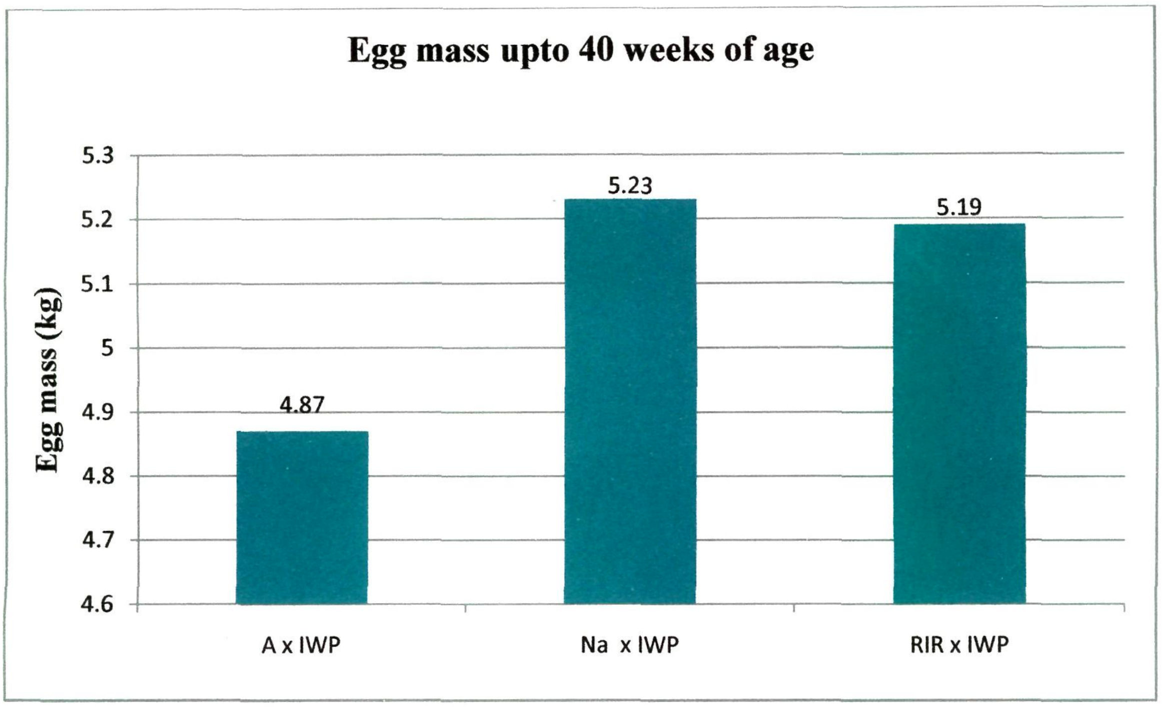


Figure 4.7: Mean total feed consumption from 21-40 weeks of age (TFC_{40})

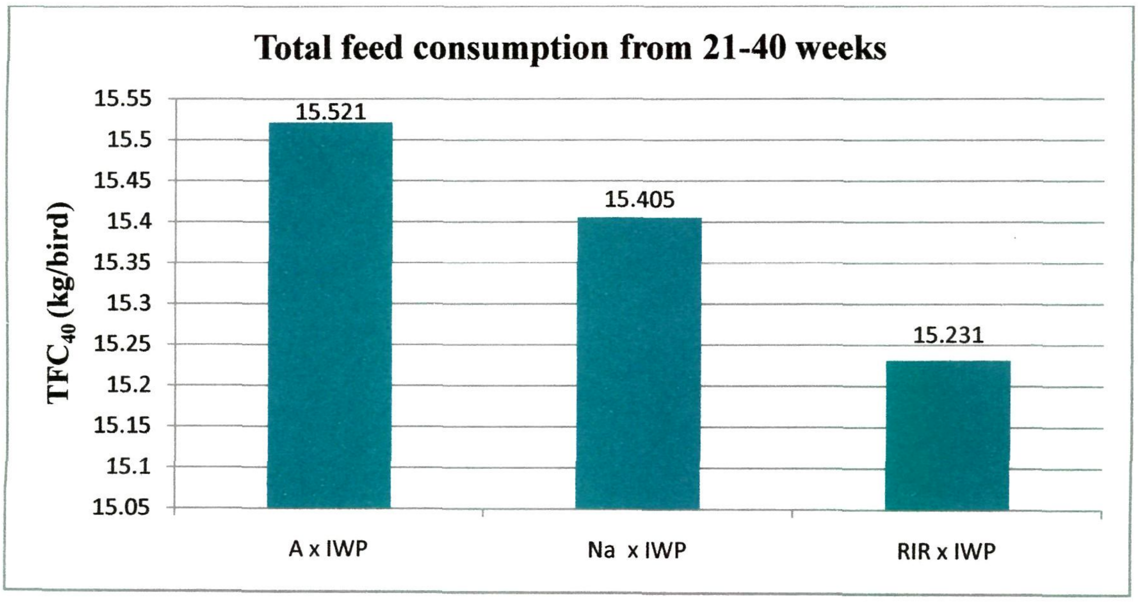


Figure 4.8.1: Feed consumption (g) per egg (FC/E)

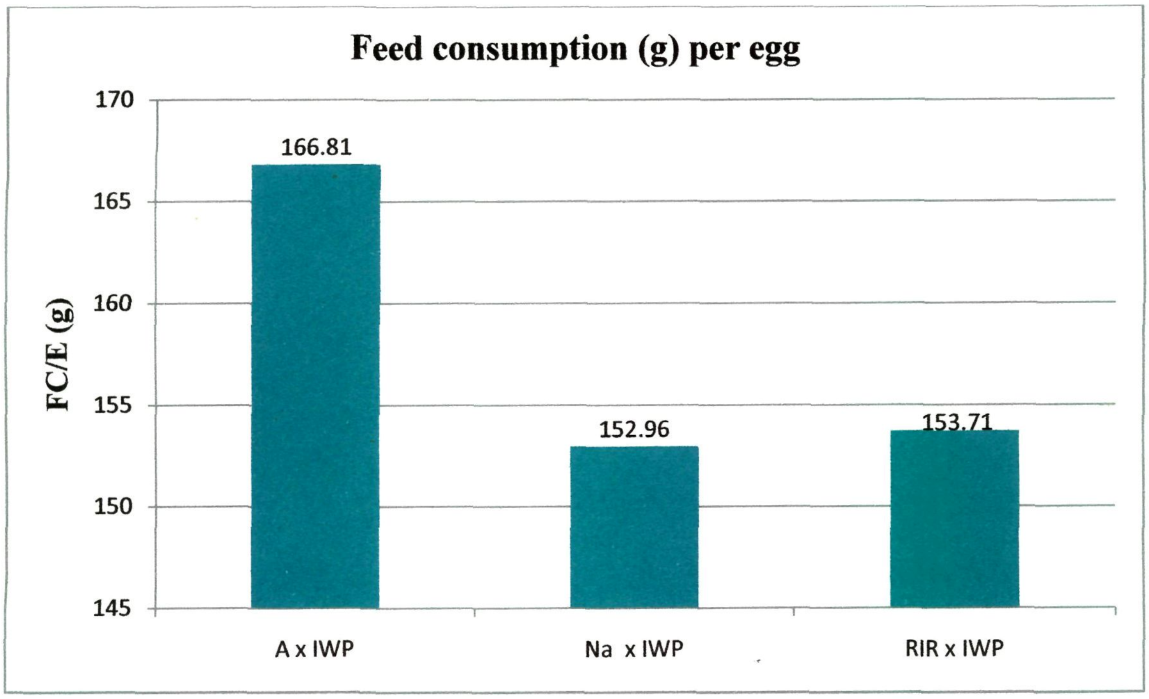


Figure 4.8.2: Feed consumption (kg) per dozen eggs (FC/DE)

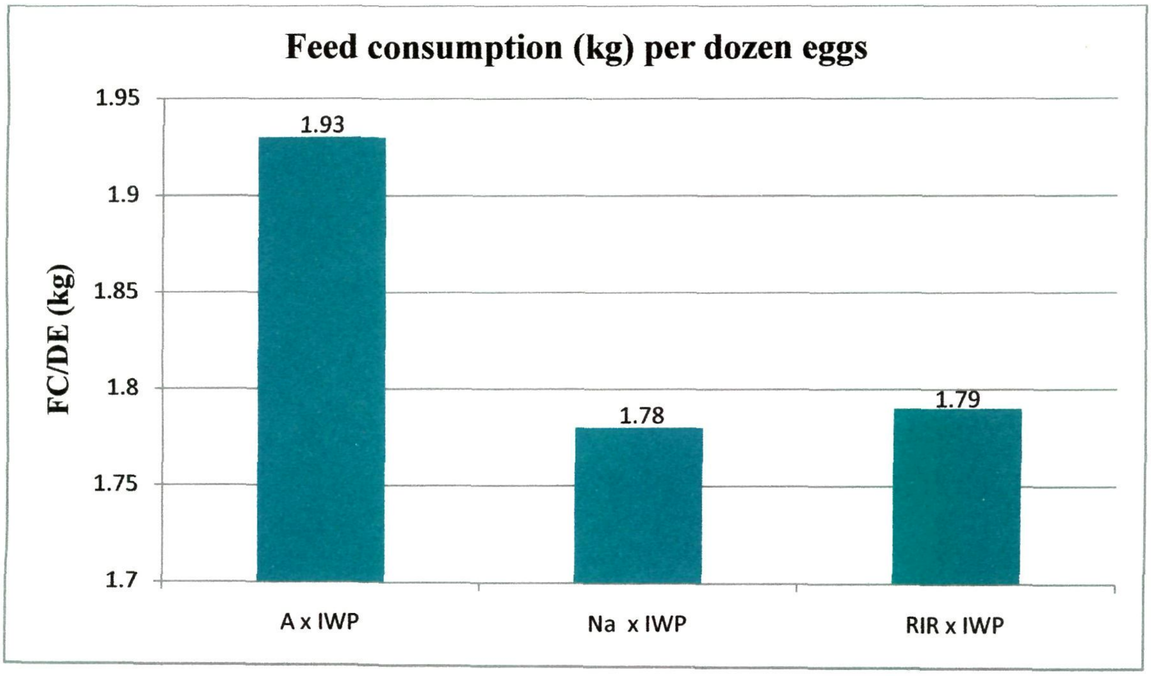


Figure 4.8.3: Feed consumption (KG) per kilo eggs (FC/KE)

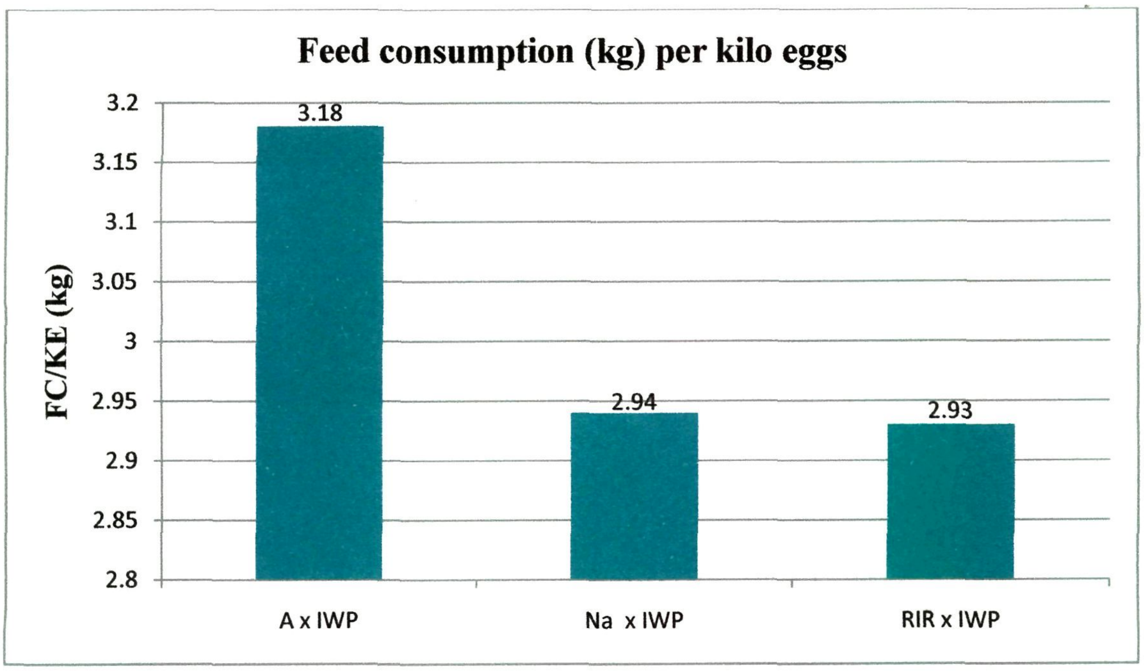


Figure 4.10: Livability percentage (0- 40 weeks of age)

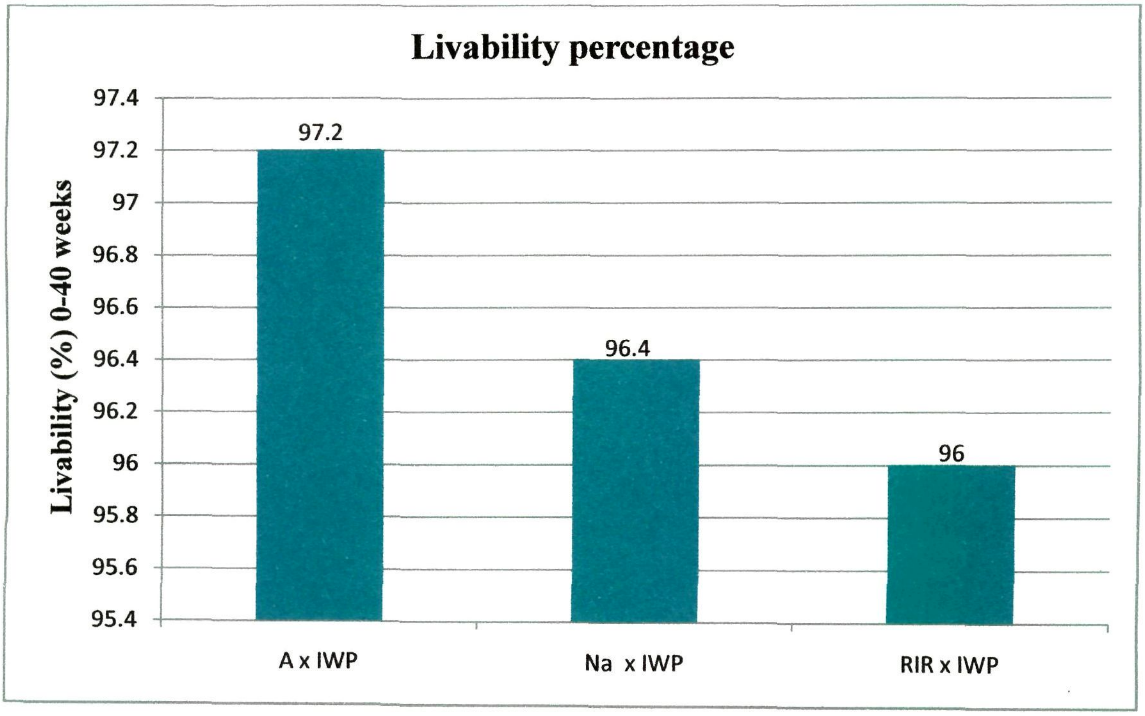
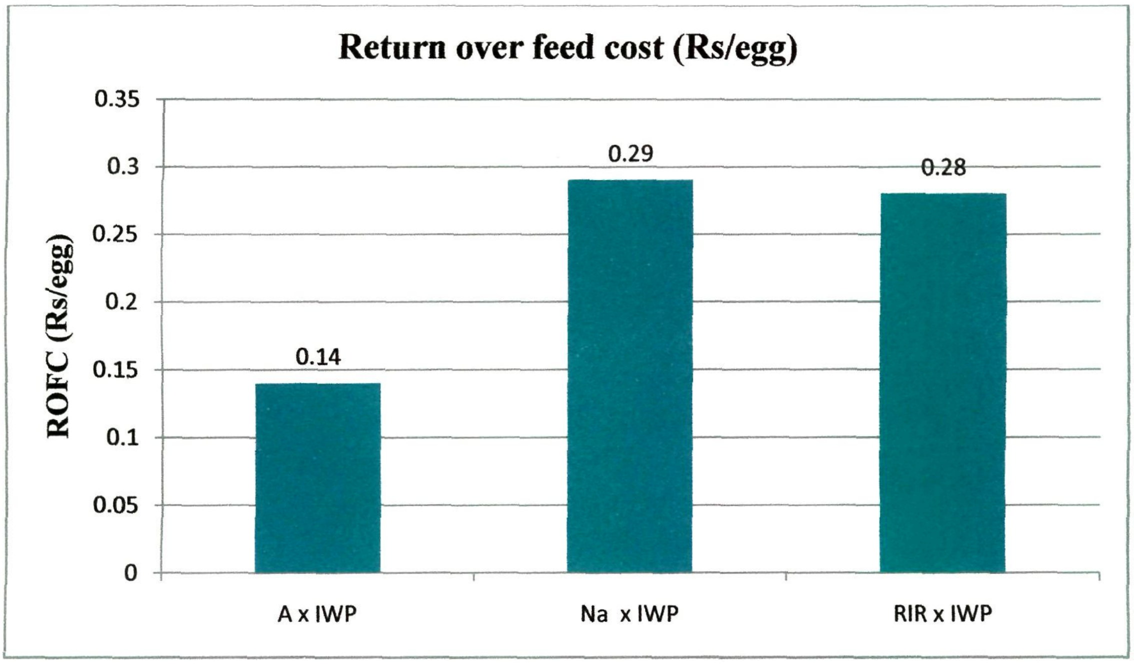


Figure 4.11: Return over feed cost (Rs/egg) (ROFC)



SUMMARY AND CONCLUSIONS

CHAPTER V SUMMARY AND CONCLUSIONS

The rural poultry farming carries more importance in developing countries because it provides employment in rural areas, women employment, strengthen rural economy and also rural requirement. Crossbreeding is most utilized to have benefits of combine desired traits in poultry improvement. Hence, more emphasis has been recently directed towards evolving birds with specific traits for rural adaptability so they would be acceptable at household level in the rural areas.

The present research work was undertaken to compare and evaluate performance of three crossbreds by mating of males of Australorp (A), Naked neck (Na) and Rhode Island Red (RIR) with the females of White Leghorn (IWP strain). The total 554, 543 and 521 chicks of A x IWP, Na x IWP and RIR x IWP, respectively were generated. The chicks were brooded and reared under standard health and managemental practices. Total 160 pullets from each cross (total 480) were housed individually in California cage system for individual performance recording and were served as experimental material for the study.

The following are the main objectives for the study:

1) To study the growth performance and sexual maturity of three crossbreds.
2) To study the egg production performance of three crossbreds upto 40 weeks of age.
3) To study the feed consumption and related feed efficiency traits.
4) To evaluate the fertility and hatchability percent of three crossbreds.
5) To study livability percent of crossbreds.
6) To study the economics of crossbreds.
7) To compare performance.

The data on various traits recorded were analyzed using Completely Randomized Design (Snedecor and Cochran, 1980).

The fertility percent was found to be 97.83, 96.33 and 95.83 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. The hatchability percent on total egg set basis was recorded to be 92.33, 90.50 and 86.83 and on fertile egg set basis was recorded to be 94.37, 93.94 and 90.60 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. A x IWP crossbred had better fertility as well as hatchability as compared to Na x IWP and RIR x IWP crossbreds.

The mean body weights (g) at day old age (BW_0) was found to be 32.31 ± 0.20, 33.01 ± 0.20 and 33.87 ± 0.20 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. The BW_0 in RIR x IWP crossbred was significantly ($P<0.05$) higher as compared to other crossbreds.

The mean body weight (g) at BW_4, BW_8, BW_{12}, BW_{16}, BW_{20}, BW_{ASM}, BW_{24}, BW_{28}, BW_{32}, BW_{36}, and BW_{40} were found to be 196.44 ± 2.77, 572.60 ± 4.60, 990.02 ± 8.02, 1270.29 ± 9.20, 1627.56 ± 15.27, 1728.81 ± 14.44, 1892.97 ± 12.62, 1976.79 ± 13.64, 1886.11 ± 14.53, 1835.79 ± 15.78, 1790.72 ± 16.15 in A x IWP crossbred and 184.76 ± 2.74, 509.74 ± 5.39, 935.68 ± 7.11, 1207.79 ± 7.05, 1441.78 ± 9.91, 1548.17 ±10.66, 1662.40 ± 11.68, 1760.36 ± 13.35, 1703.71 ± 13.36, 1675.66 ± 14.08, 1678.35 ± 14.31 in Na x IWP crossbred and 195.91 ± 2.20, 512.88 ± 4.22, 943.86 ± 6.14, 1274.57 ± 6.15, 1562.87 ±8.40, 1667.78 ± 8.88, 1775.72 ±9.59, 1839.53 ±12.36, 1748.07 ±11.93, 1709.84±12.95, 1651.14±12.80 in RIR x IWP crossbred, respectively. The body weights was significantly ($P<0.05$) higher at all ages in A x IWP crossbred as compared to Na x IWP and RIR x IWP crossbreds.

The sexual maturity traits were measured as average age at first egg (days) at 10% egg production, age at 50% egg production. The age at 10% egg production was found to be 145, 142 and 141 days and at 50% egg production it was recorded to be 167, 165 and 163 days in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. The age at 10% and 50% egg production was higher in A x IWP crossbred as compared to Na x IWP and RIR x IWP crossbreds. The average age at first egg was found to be 157.68 ± 0.65, 153.71 ± 0.36 and 153.56 ± 0.39 days in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. The average age at first egg was significantly ($P<0.05$) higher in A x IWP crossbred as compared to Na x IWP and RIR x IWP crossbreds.

The hen housed and hen day production percent were calculated for 21-40 weeks period. The hen housed production percent was found to be 65.70, 72.67 and 70.00 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. The hen day production percent was found to be 67.52, 73.45 and 71.32 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. The hen housed and hen day egg production percent were higher in Na x IWP crossbred as compared to A x IWP and RIR x IWP crossbreds.

Mean egg production (No) up to 40 weeks of age (TEN_{40}) was found to be 96.11 ± 1.28, 103.54 ± 1.26 and 101.86 ± 1.26 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. The Na x IWP and RIR x IWP crossbreds had significantly ($P<0.05$) higher TEN_{40} as compared to A x IWP crossbred.

Mean egg weight (g) at 28 weeks of age (EW_{28}) was found to be 50.55 ± 0.23, 50.22 ± 0.23 and 51.20 ± 0.23 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. The EW_{28} was significantly ($P<0.05$) higher in RIR x IWP crossbred as compared to A x IWP and Na x IWP crossbreds. All the three crossbreds were found to be at par with regards to weight at all the ages.

Mean egg mass (kg) up to 40 weeks of age (TEM_{40}) was found to be 4.87 ± 0.06, 5.23 ± 0.06 and 5.19 ± 0.06 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. The Na x IWP and RIR x IWP crossbreds were significantly ($P<0.05$) higher TEM_{40} as compared to A x IWP crossbred. However, there was no significant difference in TEM_{40} between Na x IWP and RIR x IWP crossbreds.

Mean total feed consumption (kg/bird) for 21-40 weeks period (TFC_{40}) was found to be 15.529 ± 0.019, 15.405 ± 0.028 and 15.231 ± 0.019 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. However, the difference was statistically non significant.

Mean feed consumption per egg during 21-40 weeks (FC/E_{21-40}) was found to be 166.81 ± 2.83, 152.96 ± 2.26 and 153.71 ± 2.34 (g) in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. The FC/E_{21-40} was significantly ($P<0.05$) higher in A x IWP crossbred as compared to Na x IWP and RIR x IWP crossbreds. However, no significant difference was observed in FC/E_{21-40} between Na x IWP and RIR x IWP crossbreds.

Mean feed consumption per dozen eggs for 21-40 weeks period (FC/DE_{21-40}) was found to be 1.93 ± 0.02, 1.78 ± 0.02 and 1.79 ± 0.01 (kg) in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. The FC/DE_{21-40} was significantly ($P<0.05$) higher in A x IWP crossbred as compared to Na x IWP and RIR x IWP crossbreds. There was no significant difference in FC/DE_{21-40} between Na x IWP and RIR x IWP crossbreds.

Mean feed consumption per kilo eggs during 21-40 weeks (FC/KE_{21-40}) was found to be 3.18 ± 0.04, 2.94 ± 0.03 and 2.93 ± 0.04 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. The FC/KE_{21-40} was significantly ($P<0.05$) higher in A x IWP crossbred as compared to Na x IWP and RIR x IWP crossbreds. The FC/KE_{21-40} was not differed significantly between Na x IWP and RIR x IWP crossbreds.

Mean Haugh unit (HU) was found to be 69.30 ± 2.08, 64.8 ± 1.62, 60.82 ± 2.20 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. The Haugh unit was significantly ($P<0.05$) higher in A x IWP crossbred as compared to RIR x IWP crossbred. However, there was no significant difference in Haugh unit between A x IWP and Na x IWP crossbreds. Mean Albumin index, Yolk index, Yolk color and Shell thickness were at par for A x IWP, Na x IWP and RIR x IWP crossbreds.

All three crossbreds had excellent livability during the experimental period. Livability (%) during 0-40 weeks was found to be 97.2, 96.4 and 96 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively.

Return over feed cost (Rs./egg) was found to be 0.14 ± 0.04, 0.29 ± 0.03 and 0.28 ± 0.03 in A x IWP, Na x IWP and RIR x IWP crossbreds, respectively. The ROFC was significantly ($P<0.05$) higher in Na x IWP and RIR x IWP crossbreds as compared to A x IWP crossbred. There was no significant difference in ROFC between Na x IWP and RIR x IWP crossbreds.

CONCLUSIONS:

1. A x IWP crossbred has better fertility and hatchability as compared to Na x IWP and RIR x IWP crossbreds.
2. A x IWP crossbred has significantly ($P<0.05$) higher body weight at all ages as compared to Na x IWP and RIR x IWP crossbreds.
3. Na x IWP and RIR x IWP crossbreds matured significantly ($P<0.05$) earlier as compared to A x IWP crossbred.

4. Na x IWP and RIR x IWP crossbreds had produced significantly ($P<0.05$) more eggs of same weight resulting into higher egg mass as compared to A x IWP crossbred.
5. Na x IWP and RIR x IWP crossbreds had significantly ($P<0.05$) better feed efficiency in terms of feed consumption per egg, feed consumption per dozen eggs and feed consumption per kilo eggs as compared to A x IWP crossbred.
6. A x IWP crossbred has significantly ($P<0.05$) better Haugh unit as compared to RIR x IWP crossbred.
7. Na x IWP and RIR x IWP crossbreds have significantly ($P<0.05$) higher return over feed cost as compared to A x IWP crossbred.

Na x IWP and RIR x IWP crossbreds are better in egg production, feed efficiency and return over feed cost as compared to A x IWP crossbred. A x IWP crossbred is better in growth performance and albumin quality as compared to Na x IWP and RIR x IWP crossbreds.

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