INVESTIGATION OF VITAMINS AND SELENIUM ON PRODUCTION AND REPRODUCTIVE PERFORMANCE OF INDIGENOUS PIGEON

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CERTIFICATE

*This is to certify that the thesis entitled, **"INVESTIGATION OF VITAMINS AND SELENIUM ON PRODUCTION AND REPRODUCTIVE PERFORMANCE OF INDIGENOUS PIGEON"** Submitted to the Faculty of Animal Science and Veterinary Medicine, Sher- e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in POULTRY SCIENCE,** embodies the result of a piece of bona fide research work carried out by **TAYEABA JANNAT, Registration No. 15-06526** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.

Date: December 2022
Place: Dhaka, Bangladesh

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THIS PAPER IS DEDICATED TO MY BELOVED PARENTS AND LATE SISTER (FATIMA JANNAT)

LIST OF ABBREVIATED TERMS AND SYMBOLS

ABBREVIATION	FULL WORD
ANOVA	Analysis of Variance
BBS	Bangladesh Bureau of Statistics
BW	Body Weight
BWG	Body Weight Gain
CP	Crude Protein
CRD	Complete Randomized Design
DLS	Department of Livestock Service
DP	Dressing Percentage
DW	Dressed Weight
e. g.	For Example
et al.	and others
FI	Feed Intake
FS	Feed Supply
Ft.	Foot
FCR	Feed Conversion Ratio
GR	Growth rate
g	Gram
hr	Hour
i.e.	That is
IU	International Unit
Kcal	Kilocalorie
kg	Kilogram
LW	Live Weight
LWG	Live Weight Gain
LSD	Least Significant Difference
L	Liter
ME	Metabolizable Energy
mg	Milligram
ml	Milliliter
MS	Master of Science

ABBREVIATION	FULL WORD
No.	Number
NS	Non-Significant
P.M.	Post Meridiem
PS	Parent Stock
RH	Relative Humidity
ROS	Reactive Oxygen Species
SAU	Sher-e-Bangla Agricultural University
Se	Selenium
SE	Standard Error
SI	Shape Index
SPSS	Statistical Package for Social Sciences
SRBSs	Sheep Red Blood Cells
TGR	Total Growth Rate
Wt.	Weight
viz.	Such as
@	At the rate of
&	And
℃	Degree Celsius
>	Greater than
<	Less than
/	Per
%	Percentage
±	Plus-minus

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The Author

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BY

ABSTRACT

Today the use of insecticides, pesticides, etc. in the crop field and the unavailability of croplands due to urbanization causes a major threat to pigeon farming in the extensive system. So, now it is time to give attention to commercial farming through the intensive method of pigeon housing. The goal of this research work was to investigate the vitamins and selenium on the growth and reproductive performance of indigenous Gola pigeon in the confinement-rearing system. A total of 16 pair of (3-month-old) pigeons for a period of 9 month were used in the experiment. Pigeons were randomly distributed into 4 treatment groups; T_0 (Control), T_1 (Basal diet + Vitamin A, D, E & Se), T_2 (Basal diet + Vitamin B-complex) and T_3 (Basal diet + Vitamin A, D, E & Se + Vitamin B-complex) having 4 replication. In this study, feed intake (FI) and live weight (LW) at 23 week showed no significant differences (P>0.05) among the treatments. However, significant differences (P<0.05) were found for LWG and the growth rate of pigeons at 12 to 23 week of age. The highest LWG and growth rate were observed in the T_3 group (87.75g and 34.23%) which was treated with vitamins A, D, E, Se and B-complex, whereas the lowest was in the T_2 group. No significant differences (P>0.05) were observed in various treatments for the following parameters; egg production, egg weight, hatchability and hatch percentage. But the highest hatchability (90.63%) was noticed in the T_2 groups. There was no significant difference (P>0.05) observed for the day-old weight of the squab. However, significant differences (P<0.05) were found in weekly live weight (LW), live weight gain (LWG), weekly growth rate (GR) and dressing percentage (DP) of squab due to different supplementations. The highest LW noticed in the T_3 group was 159.35, 218.34 and 274.05g, respectively for the 1st, 2nd and 3rd week of squab. The maximum growth rate of squab was detected in the 1st week, followed by the 2nd and 3rd weeks of age. Maximal DP was found in T_3 (61.90%) and then followed by T_0 (61.54%), T_1 (59.86%) and T_2 (58.13%) groups. Whereas survivability rate and FCR were not significantly influenced (P>0.05) by different treatment groups. Yet, better FCR (4.36) was obtained in the vitamins A, D, E, Se and B-complex treated group than in other supplemental groups. Analyzing the above research findings, it was obtained that pigeons fed with vitamins A, D, E, Se and B-complex (T_3) achieved superior results than others and had a very effective impact on the growth and reproductive performance.

CHAPTER I

INTRODUCTION

Livestock is a crucial element of the integrated farming system in Bangladesh. It delivers not only a source of animal protein but also a key source of farm power services as well as employment. The livestock sub-sector creates employment generation directly about 20% and indirectly about 50% of the total population in Bangladesh (BBS, 2021-2022). The contribution of livestock to GDP is about 1.90% (BBS, 2021-2022). Bangladesh is an emerging country where the poultry industry is one of the most expanding sectors. Local chickens, ducks, and pigeons are traditionally reared in either scavenging, semi-intensive, or confinement system by the people of Bangladesh as a source of food, hobby and trial purposes (Sari *et al.*, 2008; Marques *et al.,* 2007). The whole poultry population in Bangladesh is about 3756.45 lakh (BBS, 2021-2022). Percentage of the world's poultry population is chicken 63%, duck 11%, goose 9%, turkey 5%, guinea fowl 3%, pigeons 3% and others 6% (Besbes, 2009). About 10 million and more than 68 breeds of pigeons are available in Bangladesh (Akter *et al.,* 2020).

The domestic pigeon (*Columba livia domestica*) is a pigeon subspecies that was derived from the rock dove (also called the rock pigeon) (Krautwald-Junghanns *et al.,* 2009). Domestication of pigeons happened as early as 10,000 years ago (Blechman, 2007). Humans have historically esteemed pigeons as nutritionists, companions, holy animals and messengers. Pigeons have been employed to transmit communications because of their homing skills, particularly during the world wars (Levi, 1977). The earliest Egyptians kept vast quantities of them and would sacrifice tens of thousands at a time for ritual purposes. Akbar the Great traveled with a coterie of thousands of pigeons (Gilbert *et al.*, 2014). They were used to proclaim the winner of the Ancient Olympics (Blechman, 2007). Messenger pigeons were used as early as 1150 in Baghdad and also later by Genghis Khan (fbipigeons, 2012). The domestic pigeon was fetched to America by European colonists as an easy source of diet and as a messenger. When fancy pigeons gained popularity in Europe around the 18th century, breeders there significantly increased the variety of pigeons by smuggling birds from the Middle East and South Asia and mixing various breeds to produce new ones (Gilbert *et al.*, 2014). Homing pigeons were widely utilized for military communications during the 19th century. These pigeons were still working in the 21st century by certain distant police departments in Odisha state in eastern India to afford emergency communication services following natural calamities. In March 2002, due to the increased use of the internet, it was declared that India's Police Pigeon Service messenger system in Odisha was to be retired (BBC News Online, 2002).

Since the beginning of time, Bangladesh has raised pigeons. There are various pigeon breeds and varieties are found in this country. Some fancy pigeons, such as the crowned pigeon, Jacobin, Fantail, Pouter, Swallow, Bokhara trumpeter and Frill back, are raised in Bangladesh as pricey products and lead noble lifestyles (Kabir, 2015). One of the most ancient pigeons on the Indo-Bangladesh subcontinent is called Giribaz. There is a lot of artificial selection used to produce tumbler pigeons. In Bangladesh's perspective, tumblers are quite old (Kabir, 2015). About 50% of farmers preferred Gola, followed by 37.5 percent Giribaz, 5% Siraji, 5% Serting and 5% Mayouri/local breed of pigeon (Islam, 2010). Gola pigeon is small in size. The other name of the gola pigeon is a band-tailed pigeon. Its length is about 30 cm (11.8 in) and its weight ranges between 270 to 290 gm. They are easily identified by their large head and long necks. They have a black head and neck, with white patches on the wings. They have also dark eyes, although in some cases it is brown. Some contain a crown over the head. Their plumage color is white and black, with white wings (Farming Haven, 2022). Pigeons are opportunistic eaters and do best on a diet of whole grains and little grit. They also need clear water (Anggorodi, 1995). Among different types of feed ingredients, pigeons mostly like corn, wheat, soybean, and peas (Alwazzan, 2000). The amount of feed provided to the pigeon is about 32.5-42.5 g/day in a semi-intensive system (Islam, 2010). Relatively modest initial investment; lower feed and housing costs; simple and economical husbandry procedures; a short reproductive sequence; quick squab growing; early sexual maturity i.e., 5 to 6 months of age and lower incidence of disease observed in pigeons. They are also environmentally friendly and have an aesthetic point of view (Asaduzzaman *et al.*, 2009). The meat which is obtained from the early age of pigeons is called squab meat. The Swedish word "skvabb" means "loose, fat flesh," hence the term "squab" is most likely of Scandinavian origin (Merriam-Webster's Collegiate Dictionary, 2009). People of all faiths like squab meat. Meat from squabs is extremely slender, effortlessly digestible, and full of vitamins, minerals, and proteins. It can also be used to make savory, delicate, and fancy meat (Hoque *et al.,* 2021; Morgan, 2006; Aliza, 2005; Canova, 2005). Squab is served at joyful feasts for holidays like Chinese New Year because Chinese people believe that pigeon meat has curative properties (Hsiung *et al.,* 2005). The squabs have a great demand in the market as a nutritious diet for patients, infant mothers and old people. Although the climate and massive ranges of crop fields along with housing premises of Bangladesh are suitable for pigeon farming and also provide an alternative source of animal protein but today due to the use of insecticides, pesticides, etc. in the crop field and the unavailability of croplands due to urbanization causes the major threat for pigeon farming in the extensive system. These also cause health hazards and even death of scavenging pigeons. So, now it is time to give attention to commercial farming through the intensive method of pigeon housing. Modern methods of raising pigeons are much more profitable than the traditional way. So, to properly start and succeed in the pigeon farming business, have to use modern rearing techniques and take care of pigeons. The balance ration is one of the vital wants for successful pigeon farming. It needs about 16%-18%CP and Energy ME Kcal/Kg: 2700-3000 (poulvet.com, 2014). Vitamins and minerals are also vital for pigeons. They are important for immunity, metabolism, fertility, reproduction, growth, etc. (Levi, 1972). To keep pigeons healthy and in peak performance; one must provide them with an excellent supply of necessary vitamins and minerals. By making sure they have the most important ones i.e., vitamins A, D, E, B complex and selenium (Se).

Vitamin A is crucial for growth, eye health, and the maintenance of the body's moist surfaces. The deficiency of vitamin A consequences in stunted growth, frailty, and reduced egg production (Pal, 2017). Vitamin D is necessary for the utilization of calcium (Ca) and phosphorus (P) which helps develop bones and create egg shells. Leg weakness, bent legs, rickets, stunted growth, thin-shelled eggs and decreased egg output can all be symptoms of vitamin D deficiency (Pal, 2017).

Supplementing the maternal diet with more antioxidants (Selenium, vitamin E and carotenoids) can considerably raise their concentrations in emerging chick tissues and lower their vulnerability to lipid peroxidation (Surai *et al.,* 1999; Surai and Speake, 1998a). Selenium (Se) can influence other aspects of vitamin E metabolism and distribution to target tissues. Selenium supplementation significantly affected pigeon reproductive performance, growth and overall health (Wang *et al.,* 2017). Cockerels' testicular maturation was hampered by Se shortage (Combs, 1994). Selenium is also beneficial to final-stage laying hens for retaining fertility (Agate *et al.,* 2000). To preserve the integrity of the sperm membrane, the male bird's diet must be supplemented with selenium. Increased vitamin E dosage along with organic Se may help to sustain semen quality especially when fertility and hatchability start to decline in the second half of the reproductive period (Surai, 2002). For conserving high reproductive and productive characteristics in poultry, Se supplementation in particular is regarded as a crucial preventive intervention (Surai, 2002). The concentrations of vitamin E in avian semen are, however, quite low (Surai *et al.,* 2000; Surai, 1999; Surai *et al.,* 1998a); and tocopherol recycling by other antioxidants (ascorbic acid and glutathione) may be crucial for antioxidant defense. Nutritional encephalomalacia can develop when insufficient vitamin E and selenium are consumed (Surai, 2002).

Vitamin B complex is also very important for pigeons. It has various functions. It is crucial to regulate appetite, assist in digestion, and maintain neurological health and normal growth. It is also necessary for good feathering and to keep skin healthy. The lack of this water-soluble vitamin can lead to reduced body growth, poor egg production curled toe paralysis and in some cases, even death. The shortage of vitamin B complex is also responsible for causing lesions in the mouth and feet, dermatitis besides fatty liver and kidneys, convulsions, anemia, embryonic mortality, perosis and paralysis (Pal, 2017).

So, considering the above circumstances and to make a sustainable pigeon farming system, the current study was designed for the following objectives:

i. To investigate the effect of vitamins A, D, E, Se and B-complex on live weight, growth rate, dressing percentage (DP) and feed efficiency ratio (FCR) of pigeons in a confinement rearing system.

ii. To evaluate the reproductive performance of pigeons along with their egg production, hatchability and survivability after supplementing vitamins A, D, E, Se and B-complex.

CHAPTER II

REVIEW OF LITERATURE

A review of literature is valuable and significant for the execution of any type of assessment or research which are interconnected to the recommended study for the upgrading of work. In our sub-continent, some research works have been carried out to evaluate the effect of vitamins and minerals on the performance of pigeons. But in Bangladesh, there a very few scientific studies on this topic. Findings are collected from Google Scholar, PubMed, SAU-e library, journals, books, etc. However, the outcomes of the pigeon are shown in the following headlines according to the latest-oldest basis.

2.1 Prerequisite of Feed

To feed pigeons a balanced diet and increase output, it is crucial to understand their true nutritional needs. Pigeon breed, age and season can all affect how much nutrition they need.

Four different ration types were formulated i.e., 100% corn (A), 50% corn plus 50% commercial feed (B), 100% commercial feed (C) and 30% corn plus 50% commercial feed plus 20% brown rice (D). Crumble was the product of commercial feed form. 12% crude protein, 1.5% fiber and 6% fat made up the nutritional content of feed type A; 15.5% crude protein, 2.4% fiber and 6.5% fat made up feed type B; 19% crude protein, 3.3% fiber and 7% fat made up feed type C and 15% crude protein, 2.3% fiber and 6% fat made up feed type D (Darwati *et al.*, 2010).

EI-Galil (2007) said that pigeons on the 13% CP diet gained more body weight than those fed the other three types of pigeon diets, which comprise 11, 13 and 15% crude protein and 2900 Kcal/kg of metabolizable energy.

According to Sales and Janssens (2003), adult pigeons should be fed diets with dietary crude protein contents of 12% and 18% and metabolizable energy (ME) contents of approximately 12 MJ/kg based on the production of progeny.

2.2 Feed Intake

According to Hoque *et al.* (2021), data were gathered arbitrarily from 10 farmers. A daily average of 37g of feed was consumed by each bird.

Kabir (2013) determined that on the basis of total feed consumption of mixed feed with broiler feed, each pair of pigeons required 40g of feed per day for pre-laying, which they need twice a day and 240g for suckling, which they required three times a day. There were noticeable changes in feed consumption between the egg-laying stage and the hatching or nursing period.

Islam (2010) reported that the amount of feed provided to pigeon ranges from 32.5 to 42.5g/day, with an average of 38.1g/day.

Darwati *et al.* (2010) maintained that a pair of local pigeons needed 73.04g feed per day in the pre-laying phase, 60.38g feed per day in the hatching phase and 91.75g feed per day in suckling two squabs.

Asaduzzaman (2008) noted that the quantity of feed supplied to semi-scavenging pigeons ranges from 32 to 37 g/day, with an average of 34.5g per day.

Bolla (2007) stated that one breeding pair would eat about 120g of feed i.e. 60g of feed daily/bird.

2.3 Body Weight

El-Deen *et al.* (2022) stated that a total of 475 birds from the three strains were used for the experiment, and the live body weights at hatch, 1st, 2nd, 3rd and 4th weeks of age were 14.90, 142, 214, 276 and 324g for the local Egyptian pigeon and 17.70, 171, 284, 374 and 398g for the Zagel pigeon and White Myrthes, respectively.

Hoque *et al.* (2021) found that at 30 days of marketing age, the mean body weight per squab was estimated to be between 350g and 400g.

According to Hoque *et al.* (2021) mature pigeons of the Giribaz, Deshi×Jalali, Shirajee and Deshi×Racer breeds weighed less than 300g on average; Deshi, Racer and Pure deshi weighed between 300 and 350g and Lakkha weighed less than 400g.

Islam *et al.* (2021) observed that the deshi squab's body weight was 18.74, 91.86, 151.78, 276.99 and 339.38g at 0, 7, 14, 21 and 28 days, respectively.

Akter *et al.* (2020) stated that the Gola pigeon's body weight was 334.33g instead of the usual pigeon's 519.22g.

Maity *et al.* (2020) observed that depending on the breed, adult brooding pigeons' (male and female) body weight varied from 287 to 290g.

Abdel Fattah *et al.* (2019) stated that the study comprised two experiments that enclosed the brooding stage of the squabs (4 weeks). The squab's body weight was measured at 49.05, 49.11 and 49.31g at the beginning and 469.55, 277.35 and 302.70g at the end, respectively.

Majewska and Drenikowski (2016) analyzed that Polish Owls and Warsaw Butterfly Tumblers breeds of pigeons had squab weights on the first day of 10.38 and 10.47g, respectively.

Kabir (2013) also noted that the body weight of crossed indigenous pigeons had a mean of 10.83g at day old, 39.43 at the first week, 99.29 in the second week, 146.43 at the third week and 175.14g at the fourth week, respectively. The first week of life had the smallest squab weight, while the third week had the largest.

Omojola *et al.* (2012) conveyed that mature pigeons weighed an average of 259g.

Darwati *et al.* (2010) observed that the body weight of local pigeons fluctuated from 10.9–16.2, 60–80, 93–306, 192–355, 170-340 and 135.5–340g on the day of birth until weaning (5th week), correspondingly. From week 0 to week 4, the squab weight grew. In week 5, it was declined.

Ibrahim and Sani (2010) noticed that a squab's average hatch weight was 12.55g.

Islam (2010) perceived that the live weight of squab for the Gola species at ages 20, 25 and 30 days was 213.60, 255.90 and 306.80g, respectively.

Azad (2009) stated that the body weight of a Gola pigeon squab ranged from 148.60 to 303g, with an average of 222.80g. The live weights of Gola pigeons were discovered to be 224.42g and 258.40g, respectively, at 30 and 35 days of age.

Asaduzzaman *et al.* (2009) indicated that a squab's average live weight was 258g.

Ibrahim and Bashrat (2009) established that the average body weight (BW) of squabs was 200.40g.

Asaduzzaman (2008) documented that the average squab weighed 258g, with weights ranging from 200 to 300g.

Axelson and Messonnier (2005) showed that the live body weight of pigeons was 300-600g.

Gibbs *et al.* (2001) analyzed that the body weight of both sexes ranged from 238 to 308g.

2.4 Feed Conversion Ratio (FCR)

Abdel Fattah *et al.* (2019) noted that the FCR of squab was 3.85, 2.35 and 3.37 during the brooding stage.

Darwati *et al.* (2010) stated that the FCR of squab on 0-7 days, 7-14 days, 14-21 days and 21-28 days ranged from 2.95, 3.42, 6.3 and 10.16, respectively.

El-Galil (2007) observed that the FCR (g feed/g gain) became significantly worse ($P<0.05$) by declining protein levels in the squab's diets, where 11% CP documented the lowest values.

2.5 Growth Performance

El-Deen *et al.* (2022) noted the growth rate of pigeons between 0-1, 1-2, 2-3, 3-4 and 0-4 weeks of age and GR (%) were 163, 37.2, 30.2, 13.1 and 183% in local Egyptian pigeon, 163, 50.7, 30, 12.5 and 183% in Zagel and 162, 62, 29.2, 12.3 and 186% in White Myrthes pigeons respectively. The growth rate peaked in the first week of life (162-163%), reached its minimum between 21 and 28 days of age, and thereafter gradually dropped.

Abdel Fattah *et al.* (2019) observed that during the brooding stage, the relative growth rate of squab was 162.17%, 139.82% and 143.94%, respectively.

Majewska and Drenikowski (2016) found that at 3-7, 7-14 and 14-21 days, the body weight gain (g) and growth rate (%) of squab in the Polish Owl breed were 57.18, 88.29 and 39.90g and 122.91, 74.03 and 21.76%, respectively.

Kabir (2013) noticed that the growth rate of crossed indigenous pigeons in 1st week, 2nd week, 3rd week and 4th week were 57, 76.42, 91.25 and 87.5%, respectively and the highest growth rate in 3rd week and was 91.25%.

Darwati *et al.* (2010) reported that the growth rate of squab on 0-1 week, 1-2 weeks, 2-3 weeks, 3-4 weeks and 4-5 weeks ranged from 155.58, 62.57, 23.27, 16.92 and -2.87%, respectively. The growth rate was highest in 1^{st} week, then declined from week 2^{nd} to 5^{th} with the negative growth rate occurring in the 5^{th} week.

2.6 Egg Production, Egg Weight, Shape Index, Hatchability, and Squab Production per year

Islam *et al.* (2021) noted that the highest egg weight was 20.07g in Sirajee, and the lowest was 14.47g in pure deshi pigeon. They also found that old pigeons weighing less than 300 grams lay eggs weighing 14.80-20.07 grams, pigeons weighing 300-350 grams lay eggs weighing 14.47-19.19 grams and pigeons weighing 350-400 grams lay eggs that weigh less than 25 grams. The average shape index of the deshi pigeon was 74.25%.

Majewska *et al.* (2021) conveyed that the fertilization rate and hatching rate of squabs from fertilized eggs were 80.0% and 75.8%, respectively.

Akter *et al.* (2020) found that hatchability (%) ranges from a low of 76.43 in the pouter breed to a maximum of 90.00 in the Gola breed. 80.63 was the average hatchability (%). Squab production (per year) ranged from a maximum of 9.22 in nuns to a minimum of 6.33 in rain, and it was 7.56 in the case of the Gola breed. In the study area (Rajshahi district), the hatchability (%) was higher in native or local pigeons than in exotic or fancy pigeons. There was no statistically significant difference (P>0.05) between the pigeon breeds in terms of egg production.

Majewska and Drenikowski (2016) studied two breeds of pigeon i.e., Polish Owls and Warsaw Butterfly Tumblers. Both breeds of pigeons laid eggs of similar weight, 14.82–14.85 g on average. The egg shape index in Polish Owls was 73.04%, whereas in Warsaw Butterfly Tumblers it was approximately 3% higher. The fertilization rate in Polish Owls was low, at 64.86% of eggs, while in Warsaw Butterfly Tumblers it was 25% greater. The hatchability (%) in Polish Owls and Warsaw Butterfly Tumblers were 97.92 and 69.57% respectively.

Kabir (2013) quantified that this research had been done to evaluate the productivity of crossed indigenous pigeon (*Columba livia domestica*) fed with mixed and broiler grower in pre-laying, after hatch (7 days) and above 7 days which was squab suckling phases in semi-intensive cages. The result indicates that average egg production was 2 eggs/period (1.75), the average egg weight was 11 g (11.17) and the percentage of hatching rate was 98.92.

Darwati *et al.* (2010) specified that data were placid from 124 birds that were reared under an intensive management system. The mean egg weight of local pigeons was 17.7 g, shape index 75.7% and hatchability 77%. The average egg production was 1.8 eggs/pair/period.

Abdel-Azeem *et al.* (2007) said that pigeon eggs ranged in weight from 13.78 to 17.38 grams.

Khargharia *et al.* (2003) observed that the hatchability (%) was relatively higher in the monsoon (84.98) than in the premonsoon (80.01) season, the overall hatchability being 78.64-82.62% under the traditional system.

2.7 Dressing Percentage of Squab

Majewska *et al.* (2021) documented those pigeons slaughtered at 6 weeks of age had better slaughter performance (66.1%) than pigeons slaughtered at 4 weeks of age (60.4%).

Hasan *et al.* (2016) stated that the Giribaz squab dressing percentage (25-35 days) was 53.88%.

Omojola *et al.* (2012) established that the Kura, Jamul, and Algardi strains of pigeons had dressing percentages (DP) of 66.72, 66.18 and 65.15 percent, respectively.

Azad (2009) observed that the squab's dressing yield was 53.92%.

Ibrahim and Bashrat (2010) reported that pigeons had a DP% of 62.15 (62.10% for males, 62.20% for females, 65.27% for adults and 59.03% for squabs).

Bolla (2007) noted that the dressing percentage of squabs was 74%.

Bokhari (2002) specified that the DP% of squabs ranged from 58.33 to 61.54% with an average of 59.94%.

2.8 Survivability/Mortality of Squab

Majewska *et al.* (2021) documented that the average mortality rate of squabs was 8.6%.

Maity *et al.* (2020) observed that pigeon mortality rates varied from 5 to 15%.

Abdel Fattah *et al.* (2019) stated that during the brooding phase, the survival rate for squabs was 100, 65 and 85%, respectively.

Darwati *et al.* (2010) found that in groups A (100% corn), B (50% corn+50% commercial feed), C (100% commercial feed) and D (30% corn+50% commercial feed+20% brown rice), mortality (%) was 37.5, 27.27, 0 and 43.75%, respectively.

Asaduzzaman *et al.* (2009) noted that the mortality rate of pigeons was 6.67%.

Khashaba and Mariey (2009) noticed the livability percentage of pigeons was 60 to 75% after supplementation of vitamins and minerals.

2.9 Effects of Vitamin A, D, E, Se and Vitamin B-complex on Body Weight of Squab

Ghita *et al.* (2021) mentioned that the research was done on 2 experimental groups i.e., group 1: control group (no food supplement was administered); group 2: experimental group (0.1 ml Selevit solution which contains vitamins, amino acids, and trace elements and it was administered orally, daily, during the study). The body weight of squab in group 1 on the 1st day, 7th day, 14th day, 21st day and 28th day was 16.4, 67.5, 171.3, 346.6, 424.1g and in group 2 was 15.9, 72.4, 189.2, 412.2 and 574.7g respectively. It was detected that on the first day of the experiment, the typical body weight of the pigeon in group 2 was 3.05% less than the average body weight of the pigeons in the control group. On the 7th day of the trial, the mean body weight of the squab in group 2 was higher than the mean body weight of the squab in group 1 by 7.26%, the difference being statistically significant ($P<0.05$). Similarly, on the 14th, 21st day and 28th day of the study, the mean body weight of the pigeon chicks in group 2 was higher than the average body weight of the pigeon chicks in the control group by 10.45, 18.93 and 35.51%, respectively.

Khashaba and Mariey (2009) defined that research was conducted to evaluate the effects of the inclusion of different levels of Vit. + Min. premix on productive and reproductive performance of pigeons under Egyptian conditions. The supplementary

Vit. + Min. premix levels were 1, 2, 3, 4, and 5g /kg of diet. Diets were prepared in mash form containing 15.64% CP and metabolize energy of 2752 Kcal /kg of diet. The hatch weight (g), weight in 7 days (g), wt. in 14 days (g), wt. in 21 days (g) and weaning weight (g) at different dietary levels of 1g/kg, 2g/kg, 3g/kg, 4g/kg and 5g/kg was 9.65, 11.76, 12.13, 14.08, 14.53g; 56.96, 64.88, 69.09, 80.31, 84.16g; 133.22, 145.41, 149.85, 164.32, 84.16g; 198.54, 216.88, 228.53, 236.21, 239.61g; and 226.62, 242.11, 277.46, 294.99, 301.45g, respectively.

2.9.1 Effects of Vitamin A, D, E, Se and Vitamin B-complex on the Body Weight of the Adult Pigeon

Khashaba and Mariey (2009) observed the average initial, final, and change in body weight (g/bird) of mature pigeons at different dietary levels of Vit. + Min. premix i.e. 1g/kg, 2g/kg, 3g/kg, 4g/kg, and 5g/kg were 302.80, 303.03, 303.23, 302.47, 303.04g; 294.80, 298.79, 302.51, 305.71, 308.39g; and -8.00, -4.24, 0.27, 3.23, 5.35g, respectively.

2.9.2 Effects of Vitamin A, D, E, Se and Vitamin B-complex on the Reproductive Performance of the Pigeon

Khashaba and Mariey (2009) also noticed that no. of egg production, egg weight (g), hatchability (%), total feed intake of pairs (g) without squab during 28 days, and total feed intake of pairs (g) with squab during 28 days at different dietary levels of 1g/kg, 2g/kg, 3g/kg, 4g/kg, and 5g/kg was 4.12,4.25, 5.50, 6.62, 6.87; 12.07, 12.62, 13.36, 15.50, 15.41g; 46.45, 55.62, 75.21, 88.98, 92.85%; 3241.00, 3115.00, 2884.00, 2758.00, 2726.50g; and 4103.75, 3850.00, 36.23.37, 3547.25, 3329.37g, respectively.

2.9.3 Effects of Supplementing Vitamins A, D and E on the Production Performance of Poultry

Surai and Kochish (2019) declared that the main antioxidant ingredients in poultry feed were vitamin E, selenium and carotenoids.

Ferdous *et al.* (2018) quantified that vitamins could be combined with water to improve biochemical profiles, hematological indices and BWG without having any negative effects on broiler chickens.

Marques *et al.* (2011) assumed that supplementation of vitamins A, D and E in the diet of Japanese quails did not deteriorate the productive performance or the interior and exterior quality of the eggs, except the supplementation of vitamin D which raises intake. When these vitamins were added to the diet of quails, cholecalciferol, retinol and tocopherol were effectively incorporated into the yolk, showing that this boosted the egg's nutritional value.

Kamalzadeh *et al.* (2009) concluded that broiler chick performance was improved by using the correct proportions of the fat-soluble vitamins and a vitamin emulsion made up of the vitamins A, D, E and K.

2.10 Effects of Vitamin A Supplementation on the Performance of Poultry

According to Alagawany *et al.* (2021), vitamin A generally enhances poultry's reproductive system, immunity and productive performance.

Abd El-Hack *et al.* (2019) stated that supplementing vitamin A and vitamin E in Bovans Brown laying hens with 0, 8000 and 16000 IU/kg of feed and 0, 250 and 500 mg/kg of feed, respectively, may help to mitigate the adverse effects of high ambient temperature. For birds subjected to heat stress, it was recommended to utilize 16,000 IU of vitamin A and 500 mg of vitamin E per kilogram of feed.

Feng *et al.* (2019) observed that the effects of vitamin A on the growth performance of White Pekin ducks were investigated in a dose-response experiment using 8 supplemental vitamin A levels (0, 500, 1000, 1500, 2500, 3500, 7000 and 14000 IU/kg). Eight treatments were created at random from 512 male Pekin ducks that were one day old, and each treatment had eight replication pens of eight ducks. From hatch through age 21 all of these ducks were kept on wire-floor enclosures. Growth performance was assessed at 21 days. The ducks fed a basic diet without additional vitamin A showed the lowermost weight gain and feed consumption overall. Weight gain and feed intake increased quadratically as vitamin A supplementation increased ($P<0.05$). Finally, it was determined that growth performance could be affected by vitamin A deficiency.

Abd El-Hack *et al.* (2017) observed that the Hy-sex strain's productivity performance parameters were enhanced by the addition of Vitamin A (16,000 IU/kg feed).

Lin *et al.* (2002) found that 3000 and 9000 IU/kg of retinyl palmitate were added to the diets of laying hens and researchers noticed a significant impact on egg production.

Fu *et al.* (2000) established that the female quail's reproductive system, which produces large quantities of follicle-stimulating hormone, developed and grew better after vitamin A supplementation was added to their diet.

2.11 Effects of Vitamin D Supplementation on Production

Alagawany *et al.* (2021) detected that vitamin D contributed to the skeletal system's optimal performance in laying hens by fortifying the claws, beak and bones.

Adhikari *et al.* (2020) directed that in Lohmann white laying hens supplemented with an additional 3000 or 9000 IU25-hydroxyvitamin D_3 per kg of feed; 3000 or 9000 IU vitamin D_3 per kg of feed; 3000 or 9000 IU vitamin D_2 per kg of feed; and 3000 or 9000 IU vitamin D_2/kg of feed, the ostensible total tract digestibility of phosphorus was higher in the 3000 IU/kg of vitamin D_2 than in the other treatments. The incorporation of various sources of vitamin D in rations could boost the utilization of calcium and phosphorus by laying birds.

Browning *et al.* (2012) indicated that increased intake of vitamin D improves calcium and phosphorus absorption, bone strength, and ultimately the health of the legs.

Marques *et al.* (2011) showed that during the trial period, quails that received vitamin D supplements did not produce statistically different egg weights, egg production, or food conversion. However, the addition of vitamin D supplementation greatly enhanced feed consumption, exhibiting a quadratic effect. The intake increased to 1034 IU of vitamin D per kg of feed.

2.12 Effects of Supplementing Vitamin E on Reproduction

According to Abd El-Ghany (2022), broilers, layers and breeders, particularly those experiencing heat stress, got vitamin E supplementation. However, the yield and superiority of eggs, as well as fertility and hatchability, were all improved when vitamin E supplements were added to the diets of layers and breeders.

Karadas *et al.* (2017) described that 125 to 300 mg of vitamin E per kg of feed improved the feed efficiency rate, egg production and eggshell thickness of hens.

Khan *et al.* (2017) and Lin *et al.* (2004) documented that the tissue was shielded by vitamin E against lipid peroxidation brought on by the production of ROS, which in turn alters the quality of the hens' eggs.

Attia *et al.* (2016) and Sahin *et al.* (2002a) also maintained that due to vitamin E's concurrent role as a reproductive component, adding it to layer hens' diets seemed to be advantageous, especially during times of heat stress.

Ebeid (2012) stated that when exposed to heat stress, providing 200 mg/kg of vitamin E to the diet, cock may increase the quantity and motility of spermatozoa, which were pointers of the quality of the ejaculate and decrease the number of dead spermatozoa.

Ciftci *et al.* (2005) established that the quantity and quality of eggs laid by laying chickens might increase in hot, humid situations by vitamin E.

Chung *et al.* (2005) demonstrated that when layer hens get vitamin E at an amount of 250 mg/kg, the detrimental effects of heat stress may be minimized.

Mori *et al.* (2003) stated that the addition of 200, 400 and 600 mg of vitamin E/kg of feed had a negative impact on food conversion, but it did not affect egg weight or feed intake.

Kirunda *et al.* (2001) agreed that feeding vitamin E to heat-stressed hens could stop the loss in egg quality.

2.12.1 Effects of Vitamin E Supplementation on Immunity, Feed Efficiency and Meat Quality

El-Ghany and Wafaa (2022) showed that a powerful chain-breaking antioxidant and immune stimulant for both cell-mediated and humoral immunity, vitamin E has been used for centuries. The presence of vitamin E in the diet of chicken was vital for the preservation and improvement of immune system function in broilers, as well as for growth and health indices. Additionally, it increased feed efficiency in broilers. The enhancement of blood parameters and carcass characteristics or meat quality were two additional advantages of vitamin E.

Desoky (2018) reported that in broiler chickens, vitamin E supplementation at rates of 100 and 200 mg/kg of the feed may enhance performance and have an immune-stimulating impact.

According to research by Habibian *et al.* (2014), heat-stressed broiler chickens treated with 250 mg/kg of vitamin E and 0.5 mg/kg of selenium each demonstrated better health and an improved immunological response to sheep red blood cells (SRBCs).

Aravind *et al.* (2001) also conveyed that adding 75 ppm of vitamin E/kg to the diet resulted in enhanced broiler feed efficiency.

Vitamins E and C were supplemented to the feed @ 150 mg/kg and 200 mg/kg, respectively, to boost chicken growth and its immune system's response to vaccination (Rajmane and Ranade, 1994).

Kennedy *et al.* (1992) showed that adding more tocopherol to poultry diets dramatically increased FCR, average body weights and net income/bird.

According to Serman *et al.* (1992), broilers' feed efficiency increased after consuming vitamin E at doses of 60, 90 and 120 IU/kg of diet.

2.13 Effects of Vitamin B-complex on the Performance of Poultry

According to Alagawany *et al.* (2021), vitamin B complex deficit caused polyneuritis, perosis, reduction of feed consumption and curled toe paralysis and folic acid and vitamin B_{12} shortage caused anemia. A few vitamins, including vitamin B_{12}, folic acid, pantothenic acid and biotin, were necessary for the healthy growth of the erythropoietic organs. In conclusion, vitamins help birds' physiological and health status. Riboflavin was required for growth and complete good well-being in poultry. In addition, vitamin B_{12} also plays a fundamental part in homocysteine metabolism, energy metabolism, blood function and the immune system.

Hassanpour *et al.* (2016) analyzed that the formation of intestinal mucosa could be aided by vitamins, which additionally guard enterocytes from proapoptotic oxidative stress.

According to Bhanja *et al.* (2012), inoculation of vitamin B_6 (100 µg/egg) significantly boosted body weight at 28 days of age.

In ovo, vitamin B_6 supplementation (40, 60, 80 and 120 µg/egg) considerably amplified the hatchability (%) in Japanese quail (Elsayed *et al.*, 2010).

The following signs of thiamin deficiency in chicken were enumerated by Weber (2009), weakness, loss of appetite, weight loss, heart failure (sudden death syndrome), fatty liver degeneration, mucosal inflammation, atrophied ovaries and decreased egg production.

Whitehead (1980) stated the consequence of biotin supplementation of low-biotin practical diets during rearing and laying phases was studied in White Leghorn-type laying chickens. The condition of the bird at the point of lay or future laying performance was unaffected by biotin supplementation during development. Supplementing with biotin during ovulation had no positive impact on egg quantity, egg size, feed intake, or feed conversion efficiency. The layer's internal egg quality, as measured by albumen height, was marginally improved by biotin supplementation. It was determined that realistic diets include enough biotin to sustain hens' optimal egg-laying performance.

2.14 Effects of Selenium (Se) Supplementation on the Performance of Pigeon

Wang *et al.* (2017) detailed that among the four treatment groups of pigeons, T_1 received no Selenium (Se), while T_2, T_3 and T_4 received 0.5, 1.0 and 1.5 mg of Se/kg of dry matter (DM), respectively. Egg production, fertilization rate, birth rate and dead sperm rate were 35.02, 91.30, 73.77, 3.70 in T_1, 32.82, 92.77, 77.62, 2.73 in T_2, 37.26, 92.09, 79.30, 1.85 in T_3 and 29.87, 92.39, 77.35, 4.77 in T_4 group, respectively. The outcomes demonstrated that selenium supplementation had a significant impact ($P<0.05$) on pigeon reproduction. In comparison to the control group, birds fed 1.0 mg of selenium/kg produced more eggs, had a higher birth rate and produced fewer dead sperm.

2.14.1 Effects of Selenium (Se) Supplementation on the Performance of Poultry

Rizk *et al.* (2017) found that the percentage of hatchability and fertility in chickens was enhanced by organic selenium supplementation.

Huang *et al.* (2016) mentioned that the extrinsic and intrinsic pathways, as well as upstream regulators like Bcl-2 and p53, were all involved in Se deficiency-induced testicular apoptosis. Dietary Se shortages (0.033 mg of Se/kg feed) in comparison to the control in hy-line cockerels may have negative effects on reproductive organs.

Rajashree *et al.* (2014) stated that supplementing chicken breeders' diets with organic selenium (0.5 mg/kg) decreased mortality while increasing egg production, hatchability and the proportion of settable eggs.

Ebeid (2012) reported that under extreme circumstances, addition to male chickens' feed with organic Se (0.3 mg/kg) improved the quality of their sperm, including the number and motility of spermatozoa and decreased the number of dead spermatozoa.

Papazyan *et al.* (2006) observed that supplementing the diet with selenium allowed poultry to continue performing at a high level in terms of reproduction and productivity.

Deniz *et al.* (2005) evaluated that increased FCR and decreased drip loss were the results of adding organic selenium to broiler diets, which also improved the quality of meat and increased profits.

CHAPTER III

MATERIALS AND METHODS

3.1 Assertion of the Experiment

The research was conducted at the Poultry farm of Sher-e-Bangla Agricultural University, Dhaka, with 16 pair 3 months indigenous Gola pigeon were used in the experiment for 9 months from 30th May 2022 to 21st February 2023 to investigate the impact of vitamins and selenium (Se) on growth and reproductive performance of indigenous pigeons in a confinement rearing system.

3.2 Assemblage of Investigational Pigeons

A total of 16 pair of 3-month-old indigenous pigeon (*viz.* Gola pigeon) were employed in the experiment. They were purchased from known pigeon farmers in Dhaka city.

3.3 Trial Materials

In the evening, the collected pigeons were taken from the supplier to the university's poultry farm. They were housed in steel manufacturing cages which were made in earlier times. Before being put in the cages, the pigeons were weighed by a digital balance. Plastic feeders, drinkers, bowls, electric balance, wet and dry thermometers, ceiling fans, mosquito nets, vitamin A, D, E, Selenium and vitamin B-Complex, anthelmintic, liver tonic, ice box, syringes, vaccines also used in the experiment. For the first seven days, the pigeons were only fed a basic meal i.e., whole grains. Ad libitum fresh, pure drinking water was available at all times. During this time, no treatment was provided. After that, they were randomly assigned to four treatment groups for adequate handling and data collection. Each treatment had four (4) replications with one (1) pair in each replication (Table 1). Then, after a week, the experimental therapies began.

3.4 Experimental Treatments

For Vitamin A, D and E, Renasol AD3E vet (Renata Company); for the Vitamin B-complex, B-Com-Vit Liquid (Square Company) and for the Selenium, E-Sel Solution (Square Company) was used. These vitamins and selenium were supplied to the pigeons through drinking water @ 0.5ml/liter. The experimental treatments were the following:

T_0: Basal diet (Control group without vitamins & Se)

T_1: Basal diet + Vitamin A, D, E & Se (0.5ml/liter drinking water)

T_2: Basal diet + Vitamin B-complex (0.5ml/liter drinking water)

T_3: Basal diet + Vitamin A, D, E & Se + Vitamin B-complex (0.5ml/liter drinking water)

Table 1. Design of the Experiment

Treatment groups	No. of replications				Total
	R_1	R_2	R_3	R_4	
T_0	2	2	2	2	8
T_1	2	2	2	2	8
T_2	2	2	2	2	8
T_3	2	2	2	2	8
Total	8	8	8	8	32

3.5 Preparation of Trial House

The shed was an open-sided natural house. It was a tin shed gable-type house with a concrete floor. The experimental room was thoroughly cleansed and rinsed with tap water. The shed had a 1-foot side wall but no ceiling. The peak of the roof was more than 15 feet above the floor, while the floor was more than 1 foot off the ground. Before beginning the experiment, the house was disinfected with an n-alkyl dimethyl benzyl ammonium chloride (TimsenTM) solution. Four pigeon cages were put inside the shed once they had dried thoroughly. Each pigeon cage had four compartments. One pair of pigeon was present in each compartment. Cages were disinfected by spraying diluted potassium permanganate solutions ($KMnO_4$). The measurement of the cage was 6×2×1.6 ft. There were trays under every pen for the collection of droppings. Each compartment also contains an earthen pot filled with rice straw for their resting and egg-laying place. Different replications of different treatments were allocated randomly in different segments of the cage with significant markings.

3.6 Experimental Diets

A wide variety of feed ingredients (i.e., whole grains) were purchased from local markets, Savar, Dhaka to formulate a balanced ration for pigeon. The energy and protein level of the ration was maintained at 2986 ME Kcal/Kg and 18 % CP (Table 2). The Animal Nutrition and Feed Section laboratory of the Department of Livestock Service (DLS) performed an approximate analysis of all feed ingredients.

Table 2. Ration Formulation for Pigeon (Protein Based)

Name of ingredients	Amount (Kg)	Supplied CP% in ration	Supplied energy in the ration (ME) Kcal/kg
Maize	30	3.0	1050
Wheat	23	2.53	736
Soybean	14.5	5.22	455.45
Pea	20	4.4	460
Mustard	05	1.7	138.05
Black Gram	05	1.2	146.9
Grit Mixture	02		
Salt	0.5		
Total	100	18	2986

Feeds were provided twice daily and ad libitum drinking water along with its vitamin, and mineral supplements was also given in authorized amounts.

3.6.1 Assortment of vitamins A, D, E, Se and B-complex

Vitamin A, D, E, Se and B-complex were purchased from a veterinary medicine shop, in Savar, Dhaka.

3.7 Husbandry Practices

The pigeons were randomly distributed according to the experimental design in the cage-rearing system. They were fed with the mentioned diet according to treatments. Birds assigned to all treatments were subjected to the same management procedures including housing, nesting, vaccination and medication programs recommended for pigeons. All the subsequent management protocols were followed as per poultry science standards during the whole experimental period.

3.7.1 Temperature and Relative Humidity in the House

Averages of daily room temperature and relative humidity for the trial period were recorded using a thermometer i.e., a wet and dry bulb thermometer respectively. The average room temperature was 30 to 32.38° C and relative humidity (RH) was 70 to 72.23%. A curtain was used to control temperature and humidity. In hot weather, the curtain was opened and electric fans were also used to maintain the ideal temperature of the house. In cold weather and heavy rain, the curtain was closed.

3.7.2 Aeration

Aeration or ventilation in a poultry house distributes fresh air which is mandatory to sustain life. It also aids in diminishing excess temperature, humidity, and air pollution to bearable limits for confined birds. It is a challenge; however, poultry houses are different and ventilation requirements change with time of day, season, temperature, humidity, wind, bird age and density. If the air in a surrounded structure where pigeons were kept was not replenished, the air composition changes. Carbon dioxide, ammonia, and other hazardous gases reached unacceptably high levels. As the ventilation system exchanges the air in the farm, it brings in the oxygen needed to endure life and carries out the harmful gases and undesirable odors caused by respiration and waste decomposition. The system also dilutes airborne disease organisms and keeps them at a tolerable level for the birds' health. The shed was south-facing and exposed. Due to wire net cross ventilation, it was easy to remove polluted gases from the farm.

3.7.3 Lighting

The poultry farm is an open-sided natural house which is why no extra lighting was provided during the daytime especially in the summer season and only at 6 pm to 8 pm, 2hrs additional light was given. A total of 16 hours of light were provided over the winter to combat the cold. The light was given according to weather conditions.

3.7.4 Nourishing and Watering

Pre-weighed feeds were given to all treatment groups. The feeds left over were measured and deducted from the total amount of feeds offered during each four-day interval to determine the actual feed consumption of the birds during the experimental period. Treatments were given through drinking water 2 times a month for 5 days. Feeders were cleaned at four days intervals and drinkers were washed daily.

3.7.5 Incubation and Brooding

For parent stock (PS) of pigeons, incubation and brooding were done in the farmer's house and their natural incubation and brooding were performed. After the end of the brooding stage when they start to feed themselves, on that time PS of pigeons were purchased from the farmers. Later their growing stage, they came to the laying phase during the study period. Then both male and female pigeon incubated their eggs and the incubation period of pigeon eggs was 17 to 18 days. Between the laying of the first and second eggs, there was frequently a pause of one or two days. The nest was made by both parents, who also kept the eggs warm. Pigeons, both male and female, were fed their squabs. The double nest was necessary because female pigeons further started laying eggs before the squabs had left the nest. To avoid upsetting squabs and interrupting egg incubation, a double nest was employed. The pigeons received additional feed & and water during this time. The nest was cleaned at regular intervals.

3.7.6 Biosecurity Precautions

A set of management procedures known as "biosecurity" should be used to lessen the risk of introducing and disseminating disease-causing organisms from the farm. Visitors were not allowed to enter the farm, all equipment in the experimental house was kept neat and clean, and dead birds were removed immediately after death. Farms used immunization, medication and sanitation programs to prevent disease in pigeons.

3.7.7 Sanitation

Throughout the duration of the experiment, appropriate hygiene practices were upheld. A routine sanitation task included cleaning and scrubbing the shed, the pigeon cages, and the surrounding area. A mosquito net (i.e., 6 feet) was used to control flies and mosquitoes. Plastic trays and pigeon nests were regularly cleaned. After thorough cleaning and drying, a potassium permanganate solution was used to disinfect the nest, trays and cages to eliminate any leftover germs. In the shed, the staff wore farm shoes. To avoid any potential disease contamination, a foot bath filled with potassium permanganate solutions ($KMnO_4$) was utilized at the entrance to the room. During the testing phase, strict hygienic procedures were followed.

3.7.8 Immunization

The experimental birds were immunized with the vaccines by the vaccination schedule after being procured from the Department of Livestock Service (DLS). By the manufacturer's advice, distilled water was used to dilute one ampule of the vaccine. The cool chain of vaccines was maintained strictly up to vaccination. The vaccination schedule for the pigeons is shown in Table 3.

Table 3. Vaccination Schedule of Pigeon

Vaccine	Age	Route	Booster
BCRDV	4-7 days	1 drop in the eye	18-21 days
RDV	2 months or more	1 ml Intramuscular	Every 6 months interval
Pigeon Pox	3-7 days age	Wing web	No Need

3.7.9 Medication

Everyone received anthelmintic and ectoparasiticide following the manufacturer's advice. The medication program is presented in Table 4.

Table 4. Medication Program of Pigeon

Medicine	Composition	Dose	Period
Peravet powder	Anthelmintic	1g/L water	1 day (all groups)
A-Mectin Vet	Ectoparasiticide	1 drop (Pour-On)	1day (all groups)

3.8 Study Parameters

3.8.1 Recorded Parameters

The parameters were taken to determine the following production and reproduction performance of indigenous pigeons i.e., live weight, feed consumption, weekly growth rate, egg production record, hatchability%, hatch%, feed conversion ratio (FCR) of squab, survivability, squab's weekly weight gain, dressing percentage of squab. FCR was calculated from the final live weight gain and total feed intake per bird in each replication. After slaughter dressing yield of the squab was calculated for each replication to find out the dressing percentage.

3.9 Data Collection

3.9.1 Body Weight (BW)

The average group body weight was collected at 15-day intervals and data was recorded up to 23 week of age of pigeons.

3.9.2 Growth Rate (GR) of Pigeon

The average growth rate of adult pigeons was recorded up to 23 week of age.

3.9.3 Feed Intake (FI)

Daily feed intake record of each replication was kept to get four-day intervals and total feed intake record per bird.

3.9.4 Egg Production and Egg Weight

Collected data for total no. of egg production and egg weight throughout the experimental period to evaluate their reproductive performance.

3.9.5 Live Weight of Squab

The initial day-old live weight was taken as early as possible after hatching the squab. All the day-old live weights of the squab were measured in the morning. Then weekly live weight of each replication was kept to get the final live weight record per squab.

3.9.6 Weekly Weight Gain of Squab

The pigeon's squab weight gain was taken at 1st week, 2nd week and 3rd week of age.

3.9.7 Survivability of Squab

Survival rates were calculated directly according to the percentage of surviving squabs concerning the total number of squabs in each group. Each two squabs was considered to replicate with 100% survival if both were still alive, 50% of the unit if one squab died during the experiment and 0% if both squabs of the replicate had died. The survival rate for each replication was kept up for the whole experimental period to calculate survivability.

3.9.8 Dressing Processes for Squab

After 3 weeks of age, squabs were sacrificed to estimate dressing percentage (DP). All birds to be slaughtered were weighed and fasted but drinking water was provided ad libitum during fasting to facilitate proper bleeding. The halal method was used for slaughtering. Squabs were slaughtered by serving the jugular vein, carotid artery and trachea by a single incision with a sharp knife and allowed to completely bleed out at least for 2 minutes. Then the birds were soaked in warm water for 5 minutes. After that feathers were removed from the skin manually. Then singeing the squab in flame for 10 to 20 second to remove the pin feathers. Afterward, the carcasses were eviscerated and dissected according to the methods by Jones and Farrel, (1992). The heart and liver were removed from the remaining viscera by cutting them loose and then the gall bladder was removed from the liver. Cutting it loose in front of the proventriculus and then cutting with both incoming and outgoing tracts removed the gizzard. Finally, the head and shank were also removed. The shank was cut above the hock joint. Dressing yield was found by subtracting blood, feathers, head, shank, liver, heart, and digestive system from the live weight. The flow diagram for the dressing procedure of squab is shown in figure1.

Live squab

↓

Catching

↓

Slaughtering (by halal method)

↓

Bleeding (2 minutes)

↓

Scalding (soaked in warm water; temperature 60-65℃)

↓

Plucking/ Defeathering

↓

Singeing (10-20 sec)

↓

Evisceration (removal of internal contents i.e., viscera)

↓

Cutting: head, neck, shank

↓

Weight dressed carcass

↓

Storage

Figure 1. Flow Chart for Dressing Procedure of Squab

3.9.9 Dressing Yield of Squab

Dressing yield (g) = Live weight (g) - (blood + feather + head + shank + digestive system + liver + heart).

3.10 Calculations

3.10.1 Live Weight Gain (LWG)

The average body weight gain of each replication was calculated by deducting the initial body weight from the final body weight of the birds.

Body weight gain (g/bird) = Final weight (g) - Initial weight (g)

3.10.2 Growth Rate (%) of Pigeon

The average growth rate of each replication was taken by using the following formula.

$$\text{GR (\%)} = \frac{\text{Live weight gain (g)}}{\text{Initial live weight (g)}} \times 100$$

3.10.3 Feed Intake (FI)

Feed intake was calculated as the total feed consumption in a replication divided by the number of birds in each replication.

$$\text{Feed intake (g/bird)} = \frac{\text{Feed intake in a replication}}{\text{No. of birds in a replication}}$$

3.10.4 Feed Conversion Ratio (FCR)

FCR was calculated as the total feed consumption divided by weight gain in each replication. In the case of squab, FCR was calculated based on parent-fed squab.

$$\text{FCR} = \frac{\text{Feed intake (kg)}}{\text{Weight gain (kg)}}$$

3.10.5 Shape Index (SI)

It was calculated by measuring the egg length (L) and width (W) with a slide caliper to the nearest 0.01 mm. The shape index (SI) was determined from these measurements according to Reddy *et al.* (1979) and Anderson *et al.* (2004) as given with the following formula.

$$\text{SI (\%)} = \frac{\text{W}}{\text{L}} \times 100$$

3.10.6 Hatchability, Hatch

Hatchability and Hatch were calculated by using the following formula.

$$\text{\%Hatchability} = \frac{\text{No. of squab hatched}}{\text{No. of fertile eggs}} \times 100$$

$$\text{\% Hatch} = \frac{\text{No. of squab hatched}}{\text{No. of eggs set}} \times 100$$

Fertility was determined by candling eggs within the first five (5) days of incubation. It was performed in a dark room in front of the high light. During this time if blood vessels (BV's) were seen, then it was called a fertilized egg.

3.10.7 Growth Rate (%) of Squab

Growth rate (GR%) during the periods 1-7 days (GR_1), 7-14 days (GR_2), 14-21 days (GR_3) and total growth rate during the period 1-21 days (TGR) for all squab was calculated by the following equation (Brody, 1945).

$$\text{GR (\%)} = \frac{\text{W2} - \text{W1}}{0.5(\text{W2} + \text{W1})} \times 100$$

Where:

W_1 = the weight at the beginning of the period,

W_2 = the weight at the end of the period.

3.10.8 Dressing Percentage (DP)

The dressing percentage was calculated as the dressing yield divided by live weight multiplied by 100.

$$\text{DP (\%)} = \frac{\text{Dressing yield (g)}}{\text{Live weight (g)}} \times 100$$

3.10.9 Statistical Analysis

To meet the goals of the study, the total data were gathered, tabulated and analyzed. The Excel software was applied for computing initial data. Statistical Package for Social Sciences (SPSS version 26, 2010) was used to conduct a one-way ANOVA on the gathered data. Differences between means were tested using Duncan's multiple comparison tests, LSD and the significance level was set at P<0.05.

CHAPTER IV

RESULTS AND DISCUSSION

The growth and reproductive performance of Gola pigeons supplemented with vitamins and selenium are presented in Tables 5 to 8 and Figures 2 to 5 The following subheadings were used to discuss the findings.

4.1 Growth Performance of Indigenous Gola Pigeons

4.1.1 Initial Live Weight

The initial live weight at 12 week of age of Gola pigeons was presented in Table 5. Significant differences ($P<0.05$) were found among the different treatment groups. The highest live weight was seen in T_0 (298.50g) then followed by T_1 (291.50g), T_2 (280.25g) and T_3 (258.75g) groups. The grand average initial body weight of the Gola pigeon was 282.25g. It was very difficult to collect the same weight pigeons. Because they were purchased from different pigeon farmers, their management systems were also different. Khashaba and Mariey (2009) found that the mean initial body weight of a pigeon was 302.80g which was more likely similar to these results. A similar result was also observed by Gibbs *et al.,* (2001) and the value was 238 to 308g.

4.1.2 Live Weight at 23 Weeks

The effects of treatments on the live weight (gram per bird) of native Gola pigeons at 23 weeks of age were demonstrated by the data in Table 5. The basal diet's inclusion of vitamins A, D, E, B-complex, and selenium had no significant impact ($P>0.05$) on the live weight of native Gola pigeons. In the dietary groups T_0, T_1, T_2 and T_3, the average ultimate live weight (g) of Gola pigeons was 374.00, 358.75, 337.25 and 346.50g, respectively. The T_0 (control) group had the highest live weight because their starting weight was already high that’s why they displayed the maximum value. Results of the present study supported the findings of Akter *et al.,* (2020) who reported the body weight of the Gola pigeon was 334.33g. Omojola *et al.* (2012); Khashaba and Mariey (2009) and Axelson and Messonnier (2005) reported a similar result after supplementation of vitamin and mineral premix.

4.1.3 Live Weight Gain and Growth Rate (%) of Gola Pigeons

At the end of 23 week, the mean live weight gains (g) of indigenous Gola pigeons in the various treatment groups were T_0, T_1, T_2 and T_3, respectively, with values of 75.50^{ab}, 67.25^{b}, 57.00^{b} and 87.75^{a} (Table 5). The total mean live weight gain of the different treatment groups revealed a significant difference ($P<0.05$) between the groups compared to the control group. In comparison to the T_0 (control) group, T_3 (vitamins A, D, E, and Se + vitamin B-complex) had the best result (87.75^{a}) and T_2 (vitamin B-complex) had the lowest result (57.00^{b}). The mean growth rate (%) of native Gola pigeons at 12 to 23 week of age was also presented in Table 5. There was a statistically significant difference ($P<0.05$) among the various treatment groups, with the values for the T_0, T_1, T_2 and T_3 groups being 25.24^{b}, 23.25^{b}, 20.63^{b} and 34.23^{a} percent, respectively. The highest growth rate was found in the T_3 group whereas the T_2 group had the lowest figure. But, statistically T_0, T_1 and T_2 groups showed similar results. The group T_3, which contained both fat and water-soluble vitamins as well as selenium, produced superior results in terms of both live weight gain (g) and growth rate (%) in indigenous Gola pigeons at 12 to 23 week of age. These vitamins and selenium enhanced musculature, and healthy skin, regulated normal metabolic processes and strengthened the immune system. Vitamins and minerals might be used with drinking water and also provide good results in live weight gain (LWG) and growth rate without any harmful effects on pigeons (Ferdous *et al.*, 2018). Compared to the control (T_0) group, all supplements had a synergistic impact in the T_3 group, but there were no discernible benefits when only one therapy was given to the T_1 or T_2 groups. According to Khashaba and Mariey (2009), a substantial impact was found on live body weight, changes in body weight and growth rate over time at different ages while increasing vitamin-mineral premix levels in the ration.

4.1.4 Feed Intake/Pigeon/Day (g) (12 to 23 week)

Table 5 indicates the average daily feed intake of Gola pigeons from 12 to 23 week of age. No significant difference ($P>0.05$) was found among the different treatment groups. But feed intake (FI) was highest in the T_2 group (23.38 g/bird/day) and then followed by T_3 (22.25 g/bird/day), T_0 (22.06 g/bird/day), T_1 (21.85 g/bird/day) groups. The mean feed intake/pigeon/day was 22.39 ± 0.86g. Supplementation of vitamins A, D, E, B-complex and selenium had no noticeable influence on the average feed intake of native Gola pigeons. This result disagreed with these findings and was compatible with those observed by Darwati *et al.*, (2010); Khashaba and Mariey (2009); Bolla (2007) who detected better feed consumption in pigeons by using vitamins and selenium.

Table 5. Growth Performance and Feed Intake of Indigenous Gola Pigeon at 12 to 23 week of Age

Treatment	Initial LW at 12 wk (g/bird)	LW at 23 wk (g/bird)	LWG at 12 to 23 week (g/bird)	Growth Rate (%) (12 to 23 wk)	Feed intake/bird /day (g) (12 to 23 wk)
T_0	298.50^{a}	374.00	75.50^{ab}	25.24^{b}	22.06
T_1	291.50^{ab}	358.75	67.25^{b}	23.25^{b}	21.85
T_2	280.25^{ab}	337.25	57.00^{b}	20.63^{b}	23.38
T_3	258.75^{b}	346.50	87.75^{a}	34.23^{a}	22.25
Mean±SE	282.25±6.34	354.13±6.4	71.88±4.06	25.84±1.81	22.39±0.86
Level of significance (P)	*	NS	*	*	NS

Here, T_0: Basal diet (Control group without vitamins & Se), T_1: Basal diet + Vitamin A, D, E & Se, T_2: Basal diet + Vitamin B-complex and T_3: Basal diet + Vitamin A, D, E & Se + Vitamin B-complex. Values are mean ± S.E one-way ANOVA (SPSS, Duncan method), LW= Live weight, LWG= Live weight gain.

- Mean with different superscripts are significantly different (P<0.05)
- Mean within the same superscripts doesn't differ significantly (P>0.05)
- SE= Standard Error
- NS= Non-significant
- * means significant at 5% level of significance (P<0.05)

4.2 Feed Supply (FS) and Feed Intake (FI) of Pigeons During Growth and Reproductive Period

The feed supply and feed intake/pigeon/day are presented in Figure 2. There was no significant difference (P>0.05) found among the different treatment groups. Here, FS was highest in the T_0 group (49.75g) and lowest in the T_1 group (43g). In the meantime, FI in the T_0, T_1, T_2 and T_3 groups were 30.25, 29, 29 and 31.25g respectively. It should be noted that FI was comparatively low according to FS. This might be due to wastage in feed which was performed by pigeons. By their natural habit, pigeons move their head and drop the feeds to the outside of the feeder. That's why a normal feeder was not effective for pigeons' feeding purposes. Through this study, it was concluded that if a round pet bird feeder was used then wastage of feed could be reduced and feed intake also might be improved. These results were in covenant with the previous findings of Hoque *et al.*, (2021); Islam (2010) and Asaduzzaman (2008) who reported that the feed intake of an indigenous pigeon per day was 31-37g without any supplements. On the other hand present results conflicted with those made by Darwati *et al.*, (2010); Khashaba and Mariey (2009) and Bolla (2007) who documented that selenium and vitamins improved pigeons' ability to consume more feeds than without supplementations.

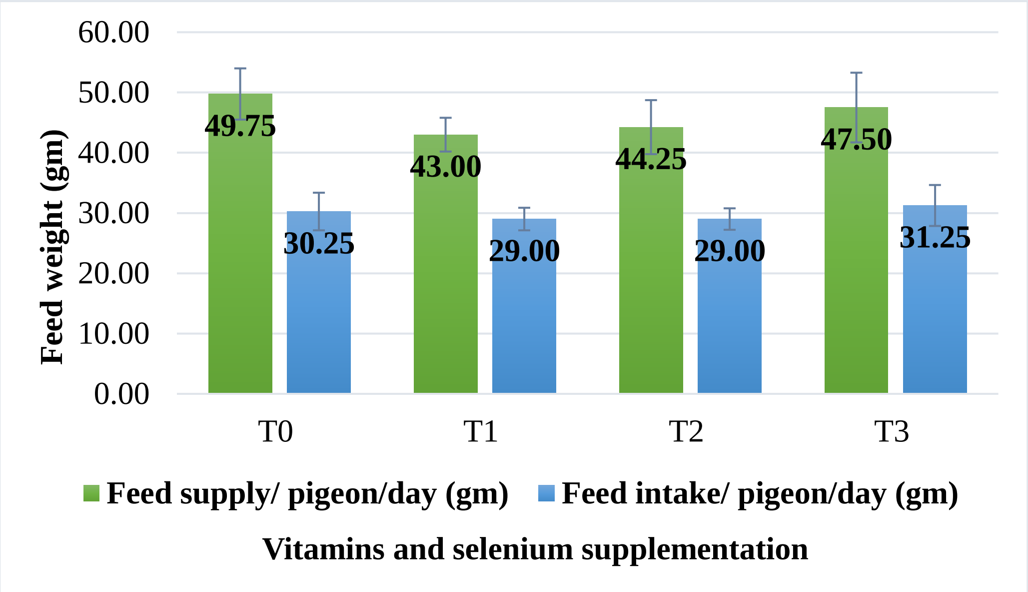

Figure 2. Average Feed Supply and Feed Intake/ Pigeon/ Day during Growth and Reproductive Period (within 9 months)

Here, T_0: Basal diet (Control group without vitamins & Se), T_1: Basal diet + Vitamin A, D, E & Se, T_2: Basal diet + Vitamin B-complex and T_3: Basal diet + Vitamin A, D, E & Se + Vitamin B-complex. The bar in each column indicates standard error.

4.3 Reproductive Performance of Indigenous Gola Pigeon

4.3.1 Egg Production

It is shown from Table 6 that in the treatments of T_0, T_1, T_2 and T_3, where the average number of eggs laid by native Gola pigeons was 10.50, 10.50, 9.00 and 11.0, respectively. The findings revealed that there was no significant difference (P>0.05) among the groups in terms of the overall mean of egg production. The average number of eggs produced was 10.25±0.44. Undesirable results were found by Khashaba and Mariey (2009) that dietary premix level had a significant effect on the egg cycle of pigeons. According to Kabir (2013) and Darwati *et al.* (2010), the average egg production was 1.8 eggs/pair/period and 1.75±0.43 eggs/pair/period, respectively which was consent above the current outcomes. Akter *et al*. (2020) also agreed with the present findings but there was no statistically significant difference (P>0.05) in the number of egg production.

4.3.2 Egg Weight

It was illustrated that the egg weight of indigenous Gola pigeons in the T_0, T_1, T_2 and T_3 groups was 16.90, 17.47, 17.01 and 16.97g, respectively (Table 6). The results revealed that there was no statistically significant difference (P>0.05) among the various treatment groups. The grand mean of egg weight was 17.08±0.21g. Although in the case of egg weight, there was no significant difference (P>0.05) observed but the highest egg weight was found in the T_1 group which was supplemented with vitamins A, D, E, and selenium, and the lowest value was found in the control (T_0) group. Vitamins A, D, E and selenium were very important for the reproduction and egg weight of pigeons. The present results were not in agreement with previous findings by Khashaba and Mariey (2009), who reported comparatively light egg weight by supplementing vitamin-mineral premix. Conversely, the findings were supported by Islam *et al.* (2021), Akter *et al.* (2020) and Darwati *et al.* (2010).

4.3.3 Shape Index

In the various treatment groups, the average shape index (%) for native Gola pigeons was T_0, T_1, T_2 and T_3, with values of 71.70^c, 74.71^b, 73.07^{bc} and 76.69^a respectively (Table 6). The total mean of egg shape index of the different treatment groups revealed a highly significant difference (P<0.05). T_3 (vitamins A, D, E and Se + vitamin B-complex) had the best result (76.69^a) and T_0 (control) had the lowest result (71.70^c). This parameter was used to determine the egg quality of pigeons. Following this, the eggs were categorized in terms of shape index (SI), namely as a sharp egg (SI < 72), a normal (standard) egg (SI = 72–76), or a round egg (SI > 76) (Sarica and Erensayin, 2009). The egg shape index was found to be accurate by Islam *et al.* (2021), Majewska and Drenikowski (2016) and Darwati *et al.*, (2010) and its values ranged from 73–76%. In a nutshell shape index should be considered for usage in breeding plans because it has an impact on several features of egg quality (Duman *et al.*, 2016).

Table 6. Reproductive Performance of Indigenous Gola Pigeon

Treatment	Egg production	Egg weight (g/egg)	Shape index (%)
T_0	10.50	16.90	71.70^c
T_1	10.50	17.47	74.71^b
T_2	9.00	17.01	73.07^{bc}
T_3	11.00	16.97	76.69^a
Mean±SE	10.25±0.44	17.08±0.21	74.04±0.55
Level of significance (P)	NS	NS	*

Here, T_0: Basal diet (Control group without vitamins & Se), T_1: Basal diet + Vitamin A, D, E & Se, T_2: Basal diet + Vitamin B-complex and T_3: Basal diet + Vitamin A, D, E & Se + Vitamin B-complex. Values are Mean ± S.E one-way ANOVA (SPSS, Duncan method).

- Mean with different superscripts are significantly different (P<0.05)
- Mean within the same superscripts doesn't differ significantly (P>0.05)
- SE= Standard Error
- NS= Non-significant
- * means significant at 5% level of significance (P<0.05)

4.3.4 Hatchability and Hatch

Data presented in Figure 3 showed that the hatchability of indigenous Gola pigeons in the T_0, T_1, T_2 and T_3 groups was 74.58, 67.08, 90.63 and 82.50%, respectively. The results revealed that the effect of treatments on hatchability was not statistically significant (P>0.05). The highest result was found in the vitamin B-complex (T_2) supplemented group and the lowest value was found in the T_1 group. Artificial incubation wasn't recommended for pigeons and here pigeons itself incubate their eggs. During the study period, some pigeons didn't incubate eggs properly, and even though they broke their eggs, ultimately hatchability was reduced. Hatchability also depends on temperature, and humidity in egg incubation time hatches. Here, the vitamin B-complex group showed the maximum hatchability this might be due to the presence of vitamin B_6. In accordance with the distinct groups, the mean hatch percentage of native Gola pigeons was 51.46, 45.21, 56.25 and 60.72%, respectively (Figure 3). There was no statistically significant difference (P>0.05) among the treatment groups T_0, T_1, T_2 and T_3, even though the T_3 group had the greatest hatch rate and the T_1 group had the lowest. Although the T_1 group also received supplements of vitamins A, D, E and selenium, the T_1 group's hatch rate (%) was lower, which may have been caused by the pigeons' actions during the incubation time. The T_1 group itself cracked the eggs before hatching at the time of the study and subsequent hatch (%) dropped. Additionally, the T_3 group had a greater hatch percentage than other treatment groups, which could be related to the availability of all vitamins and selenium as well as their calm behavior during the incubation period. In agreement with the present findings, Khashaba and Mariey (2009) noted that hatchability and hatch considerably increased when dietary premix levels increased in the diet. The current findings were also supported by Majewska *et al.* (2021), Akter *et al.* (2020) and Majewska and Drenikowski (2016). Moreover, Kabir (2013) disapproved of the present findings and discovered that native pigeons had superior hatchability.

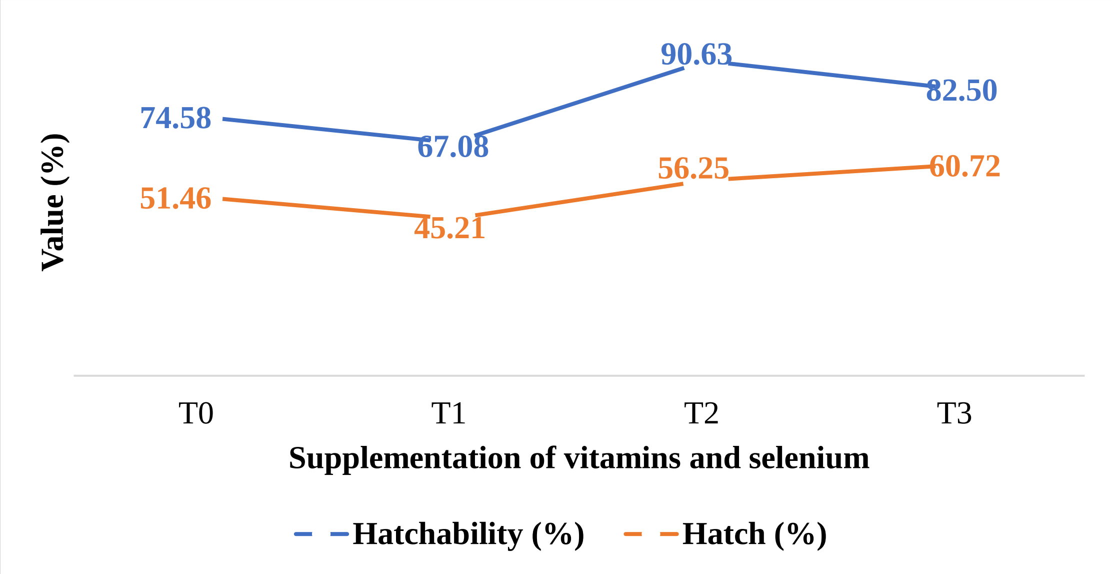

Figure 3. Hatchability and Hatch Percentage of Indigenous Gola Pigeon

Here, T_0: Basal diet (Control group without vitamins & Se), T_1: Basal diet + Vitamin A, D, E & Se, T_2: Basal diet + Vitamin B-complex and T_3: Basal diet + Vitamin A, D, E & Se + Vitamin B-complex.

4.4 Squab Performance of Indigenous Gola Pigeon

4.4.1 Weight of Day-Old Squab

The weight of day-old squabs of indigenous Gola pigeons in the T_0, T_1, T_2 and T_3 groups were 10.89, 11.10, 11.04 and 11.14g, respectively (Table 7). There was no statistically significant difference (P>0.05) found after supplementing vitamins A, D, E, B-complex and selenium. However, the highest result was observed in the T_3 group, and the lowest result in the T_1 group. Here, about 6 to 7% of the original egg weight was lost during incubation. This evidence demonstrated that during incubation, embryos needed nutrients from the egg, which the squab used to grow its organ before hatching. The results were supported by Ghita *et al.* (2021), Majewska and Drenikowski (2016), Kabir (2013) and Ibrahim and Sani (2010). Nevertheless, El-Deen *et al.* (2022), Islam *et al.* (2021), Abdel Fattah *et al.* (2019) and Khashaba and Mariey (2009) perceived different conclusions and discovered better day-old weight of squab.

4.4.2 Live Weight in 1st Week

The information in Table 7 showed the effects of supplementation on the live weight of squabs of native Gola pigeons at their first weeks of age. The addition of selenium, vitamins A, D, E and the B-complex to the basal diet significantly ($P<0.05$) affected the live weight at the first week of squab. First-week squab live weights for the T_0, T_1, T_2 and T_3 groups were 156.20^a, 143.99^{ab}, 135.58^b and 159.35^a g, respectively. Table 7 showed that the T_3 and T_0 groups both were statistically similar. Thus, the T_3 group had the highest weight, which was then followed by the T_0, T_1 and T_2 groups. El-Deen *et al.* (2022) backed up the findings in this article. However, the verdicts of Ghita *et al.* (2021), Islam *et al.* (2021) and Kabir (2013) did not coincide with the present findings and they discovered that decreased live weight of the squab at the first week.

4.4.3 Live Weight in 2nd Week

The effects of treatments on the live weight of squab of native Gola pigeons at 2nd weeks of age were revealed by the data in Table 7. The basal diet's addition of vitamins A, D, E, B-complex and selenium had no significant influence ($P>0.05$) on the live weight at 2nd week of squab. The squab live weight in 2nd week was 212.39, 207.83, 196.25 and 218.34 g for the T_0, T_1, T_2 and T_3 groups, respectively. The T_3 group had the highest weight, which was subsequently after that the T_0, T_1 and T_2 groups. El-Deen *et al.* (2022) and Darwati *et al.* (2010) observed comparable results in the second week of age of squab, which agreed with the findings of the current study. In the meantime, Ghita *et al.* (2021), Islam *et al.* (2021), Kabir (2013) and Khashaba and Mariey (2009) noticed the reduced live weight of squab and disagreed with the present findings.

4.4.4 Live Weight in 3rd Week

Data presented in Table 7 also showed the effects of vitamins A, D, E, B-complex and selenium on squab live weight at 3rd week of age. The live weight for T_0, T_1, T_2 and T_3 groups were 263.04^{ab}, 262.95^{ab}, 252.85^b and 274.05^a g, respectively. From these results, it should be concluded that different dietary treatments had a significant effect ($P<0.05$) on the live weight at 3rd week of age. The T_3 group represented the maximum value and the lowest value was found in the T_2 group. Squabs can be culled (slaughtered) at 21 days because the selection was best carried out at that age. Squabs will therefore not meet the criteria that can be defended. After 21 day, their feathers were grown properly and they resembled adult pigeons, their body weights gradually declined and consumer demands also decreased. That's why during the experiment, squabs were kept for 21 day (3 week). According to a study by Khashaba and Mariey (2009), squab-fed meals with a high premix content significantly boosted body weight during the first 28 days of life. According to Darwati *et al.* (2010), the squab weight raised the first four weeks before falling the subsequent week. The findings of the current study were also maintained by El-Deen *et al.* (2022), Islam *et al.* (2021) and Abdel Fattah *et al.* (2019). In contrast to these findings, Ghita *et al.* (2021), Hoque *et al.* (2021) and Kabir (2013) reported negative results.

4.4.5 Live Weight Gain in 1st Week

The average live weight gain (LWG) of squab in 1st week for the T_0, T_1, T_2 and T_3 groups were 145.32^{a}, 132.89^{ab}, 124.53^{b} and 148.21^{a} g, respectively (Table 7). These results indicated that there was a significant difference (P<0.05) among the different treatment groups. The highest value was observed in the T_3 group and the lowest value in the T_2 compared to the T_0 group. Ghita *et al.* (2021), Majewska and Drenikowski (2016) and Khashaba and Mariey (2009) disagreed with these findings. They observed lower weight gain during the first week. The live weight gain of squab was higher in the first week of age which was similar to an earlier report by Darwati *et al.* (2010).

4.4.6 Live Weight Gain in 2nd Week

There was no significant difference (P>0.05) found among the treatment groups for the live weight gain (LWG) of squab in 2nd week of age. In 2nd week, the highest LWG was observed in the T_1 (63.84g) group and then followed by T_2 (60.67g), T_3 (58.99g) and T_0 (56.19g) group (Table 7). These outcomes were disputed by Ghita *et al.* (2021), Majewska and Drenikowski (2016) and Khashaba and Mariey (2009). On the other hand, the current findings were sustained by Darwati *et al.* (2010).

4.4.7 Live Weight Gain in 3rd Week

For the live weight gain (LWG) of squab in the third week of age, there was no significant difference (P>0.05) among the four treatment groups. However, the T_2 group gained the highest LWG in the third week (56.61g), followed by the T_3 (55.71g), T_1 (55.12g) and T_0 (50.65g) groups (Table 7). Ghita *et al.* (2021), Majewska and Drenikowski (2016) and Khashaba and Mariey (2009) all refuted these conclusions. During this time, there was a greater weight surge than usual. Because of that their feathers were fully grown and their weight decreased. However, Darwati *et al.* (2010) deliver support for the concurrent results.

Table 7. Weekly Live Weight (LW) and Live Weight Gain (LWG) of Squab of Indigenous Gola Pigeon

Treatment	Day old wt. (g)	LW in 1st week (g)	LW in 2nd week (g)	LW in 3rd week (g)	LWG in 1st week (g)	LWG in 2nd week (g)	LWG in 3rd week (g)
T_0	10.89	156.20[a]	212.39	263.04[ab]	145.32[a]	56.19	50.65
T_1	11.10	143.99[ab]	207.83	262.95[ab]	132.89[ab]	63.84	55.12
T_2	11.04	135.58[b]	196.25	252.85[b]	124.53[b]	60.67	56.61
T_3	11.14	159.35[a]	218.34	274.05[a]	148.21[a]	58.99	55.71
Mean±SE	11.04± 0.18	148.78± 3.65	208.70± 3.69	263.22± 2.86	137.74± 3.62	59.92± 2.89	54.52± 3.19
Level of significance (P)	NS	*	NS	*	*	NS	NS

Here, T_0: Basal diet (Control group without vitamins & Se), T_1: Basal diet + Vitamin A, D, E & Se, T_2: Basal diet + Vitamin B-complex and T_3: Basal diet + Vitamin A, D, E & Se + Vitamin B-complex. Values are Mean ± S.E one-way ANOVA (SPSS, Duncan method). LW= Live weight, LWG= Live weight gain.

- Mean with different superscripts are significantly different (P<0.05)
- Mean within the same superscripts doesn't differ significantly (P>0.05)
- SE= Standard Error
- NS= Non-significant
- * means significant at 5% level of significance (P<0.05)

4.4.8 Weekly Growth Rate of Squab

At the end of the first week, the mean growth rate (%) of squab in the various groups T_0, T_1, T_2 and T_3 were 173.85[a], 171.32[ab], 169.80[b] and 173.76[a], respectively (Figure 4). The overall mean growth rate (%) of various groups differed significantly ($P<0.05$). T_0 and T_3 had the highest growth rates, while T_1 and T_2 had relatively lower rates. The average growth rate (%) of squab at the end of the second week in different groups i.e., T_0, T_1, T_2 and T_3 groups were 30.5, 36.2, 36.6 and 31.4%, respectively (Figure 4). The overall mean growth rate (%) of different groups showed that there were no significant differences ($P>0.05$) among the groups. The higher growth rate was found in T_2 and comparatively lower in the T_1, T_3 and T_0 groups. After the end of the third week, the mean growth rates (%) of the squab in the various groups T_0, T_1, T_2 and T_3 were 21.40, 23.57, 25.19 and 22.75% respectively (Figure 4). The overall average growth rate (%) of the various groups revealed that there were no significant differences (P>0.05) among the groups. However, a higher growth rate was observed in T_2 and then followed by the T_1, T_3 and T_0 groups. At last, it was concluded that the growth rate was highest in the 1st week, then decreased from 2nd to 3rd week gradually. Similar kind of results were found by El-Deen *et al.* (2022), Abdel Fattah *et al.* (2019) and Darwati *et al.* (2010). Besides, Majewska and Drenikowski (2016) and Kabir (2013) noticed divergent results, they found the highest growth rate of squab during 3rd week of age and then it reduced regularly.

4.4.9 Total Growth Rate (TGR) of Squab

For the total growth rate (TGR) of squab of indigenous Gola pigeons, there was no significant difference (P>0.05) among the four treatment groups. However, the T_2 group had the highest TGR (231.62%), followed by the T_1 (231.13%), T_3 (227.93%) and T_0 (225.71%) groups (Figure 4). Numerous factors, including genotype, age, health status, number of chicks in the nest, number of feeding parents, body weight at hatching, quantity and quality of feed and water consumed, hygienic conditions in the breeding cell and loft, the parents' ages and the standard of their care, affected the pigeon squabs' increase in body weight and growth rate (Abdel Fattah *et al.,* 2019, Miąsko and Łukasiewicz, 2017 and Gao *et al.,* 2016;). Besides, El-Deen *et al.* (2022), Abdel Fattah *et al.* (2019), Kabir (2013) and Darwati *et al.* (2010) agreed with the present findings. But Majewska and Drenikowski (2016) noticed comparatively lower TGR (Total growth rate) with these recent consequences.

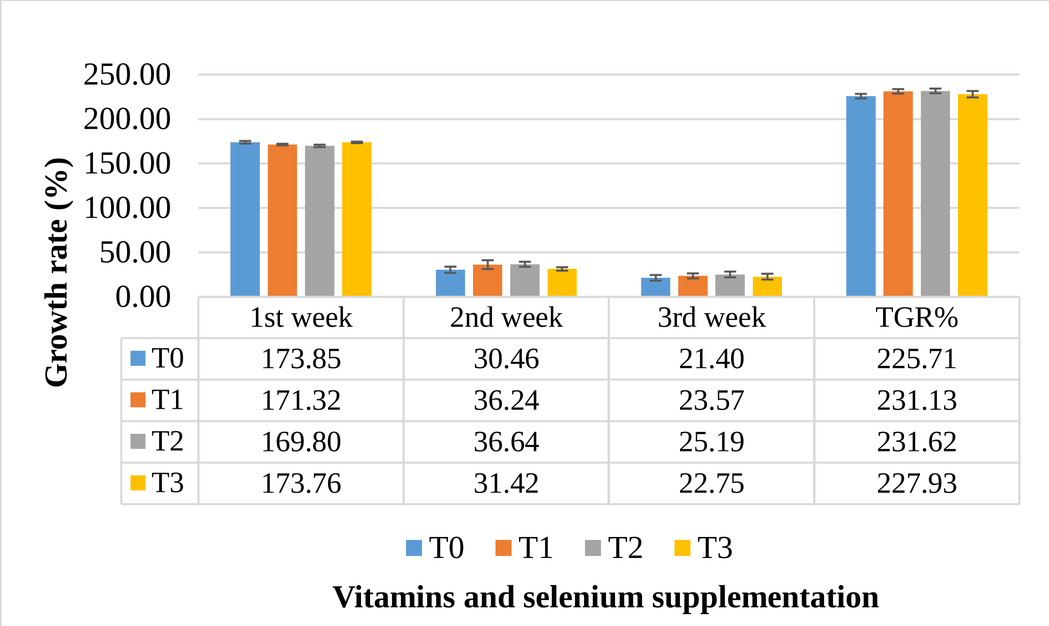

Figure 4. Weekly Growth Rate (%) of Squab of Indigenous Gola Pigeon

Here, T_0: Basal diet (Control group without vitamins & Se), T_1: Basal diet + Vitamin A, D, E & Se, T_2: Basal diet + Vitamin B-complex and T_3: Basal diet + Vitamin A, D, E & Se + Vitamin B-complex. TGR= Total growth rate. The bar in each column indicates standard error.

4.4.10 Dressed Weight

It was seen from Table 8 that the dressed weight of squabs with different types of treatment groups named T_0, T_1, T_2 and T_3 were 161.81^{ab}, 157.44^{b}, 146.96^{c} and 169.65^{a} g, respectively at 21 days. The highest dressed weight (g) was observed (169.65^{a}) in the T_3 group whereas, the lowest result belongs to T_2 (146.96^{c}) group. The results also showed statistically the T_0 group was similar to the T_1 group but a higher value was observed in the T_0 than the T_1 group. So, it was concluded that there was a significant difference ($P<0.05$) among the treatment groups and vitamins and selenium had a substantial impact on the carcass weight of native Gola pigeons. Breed, age, live weight of the birds and other factors influenced dressed weight. Gola pigeons were relatively small and that's why their carcass weight was also lower compared to meat-type exotic pigeon breeds. Majewska *et al.* (2021) found more carcass weight for king pigeons and it was about 366.67g. Agbolosu *et al.* (2021) also observed slightly higher dressed weight which disagreed with the present findings. Islam *et al.* (2021), Hasan *et al.*

(2016) and Ibrahim and Bashrat (2010) observed that dressed weights were consistent with the results of the current work.

4.4.11 Dressing Percentage (DP)

The dressing percentage (DP) of squab of indigenous Gola pigeons at 21 day for the T_0, T_1, T_2 and T_3 groups were 61.54^a, 59.86^{ab}, 58.13^b and 61.90^a %, respectively (Table 8). These results indicated that there was a significant difference (P<0.05) among the different treatment groups. The highest value was observed in the T_3 and T_0 groups, whereas the lowest value in the T_2 group. It was concluded that the higher the dressed weight higher the dressing percentage. In all species of poultry, the DP rises as live weight increases (Howlider and Rose, 1989). Therefore, it was presumed that larger breeds (King, Runt, Carneau and Homer Giant) would yield higher dressing percentages. Islam *et al.* (2021), Majewska *et al.* (2021) and Ibrahim and Bashrat (2010) agreed with the current findings on the dressing percentage of indigenous pigeon squabs. On the other hand, Agbolosu *et al.* (2021), Omojola *et al.* (2012) and Bolla (2007) observed increased DP which was not supported by the present findings. Besides, Hasan *et al.* (2016) and Azad (2009) found that 53.88% and 53.92% of DP of pigeon squab disagreed with these outcomes.

4.4.12 Survivability

Data presented in Table 8 showed that supplementation of vitamins and Se had no significant (P>0.05) effect on the survivability rate of squab of native Gola pigeons. However, the highest survivability was recorded in the T_3 group (97%) and then followed by T_0 (92.25%), T_2 (88.25%) and T_1 (86.75%), respectively (Table 8). During the experimental period, few mortalities of squabs occurred due to improper brooding of squabs by their parents and large wt. squabs ate more than the smaller ones. Because of the dominance of larger squabs' smaller ones got less chance to eat the required amount of feed, they became weak and finally, death happened. Majewska *et al.* (2021), Maity *et al.* (2020), Abdel Fattah *et al.* (2019) and Asaduzzaman *et al.* (2009) supported the above results. But, Darwati *et al.* (2010) and Khashaba and Mariey (2009), disagreed with these findings. They found the livability percentage of pigeons was 60 to 75%.

Table 8. Dressed Weight, Dressing Percentage (DP) and Survivability of Squab of Native Gola Pigeon

Treatment	DW (g)	DP (%)	Survivability (%)
T_0	161.81^{ab}	61.54^{a}	92.25
T_1	157.44^{b}	59.86^{ab}	86.75
T_2	146.96^{c}	58.13^{b}	88.25
T_3	169.65^{a}	61.90^{a}	97.00
Mean±SE	158.96±2.56	60.36±0.48	91.06±3.00
Level of significance (P)	*	*	NS

Here, T_0: Basal diet (Control group without vitamins & Se), T_1: Basal diet + Vitamin A, D, E & Se, T_2: Basal diet + Vitamin B-complex and T_3: Basal diet + Vitamin A, D, E & Se + Vitamin B-complex. Values are Mean ± S.E one-way ANOVA (SPSS, Duncan method). DW= Dressed weight, DP= Dressing percentage.

- Mean with different superscripts are significantly different (P<0.05)
- Mean within the same superscripts doesn't differ significantly (P>0.05)
- SE= Standard Error
- NS= Non-significant
- * means significant at 5% level of significance (P<0.05)

4.4.13 Feed Conversion Ratio (FCR)

Data presented in Figure 5 showed that the feed conversion ratio (FCR) was not statistically significant (P>0.05). FCR of squab at the end of the 3rd week in different groups T_0, T_1, T_2, and T_3 were 5.76, 5.34, 4.80 and 4.36 respectively. The highest FCR was found in the T_0 group compared to the T_1, T_2 and T_3 groups. In the case of FCR, a greater value denotes a poor performance while a lower number denotes a good one. Thus, the group (T_3) fed with selenium and both types of vitamins demonstrated improved feed efficiency. In this study, squab had a high feed conversion rate. This was brought on by the rapid growth that took place in the first three weeks. Results showed that feed efficiency declined with age, making local pigeons inefficient for meat producers. Darwati *et al*. (2010) searched out related FCR (3.42-6.3) within 1 to 3 weeks of age. Abd El-Galil (2007) also supported the contemporary outcomes. Abdel Fattah *et al.* (2019) disagreed with these extant results. They found comparatively lower FCR i.e., 3.85 during the brooding stage. In addition, Khashaba and Mariey (2009) observed relatively greater FCR which disagreed with the present findings.

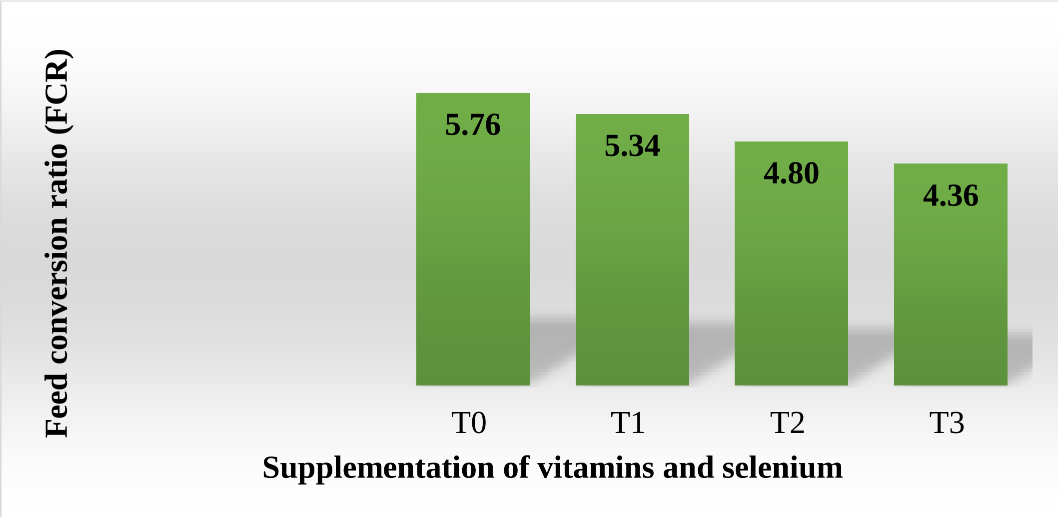

Figure 5. FCR of Squab of Indigenous Gola Pigeon

Here, T_0: Basal diet (Control group without vitamins & Se), T_1: Basal diet + Vitamin A, D, E & Se, T_2: Basal diet + Vitamin B-complex and T_3: Basal diet + Vitamin A, D, E & Se + Vitamin B-complex.

CHAPTER V

SUMMARY AND CONCLUSION

A total of 16 pair of 3-month-old indigenous Gola pigeon for a period of 9 months were used in the experiment and they were reared under a cage-rearing system at Sher-e-Bangla Agricultural University Poultry Farm, Dhaka. Pigeons were divided randomly into 4 experimental groups i.e., T_0 (Control), T_1 (Basal diet + Vitamin A, D, E & Se), T_2 (Basal diet + Vitamin B-complex) and T_3 (Basal diet + Vitamin A, D, E & Se + Vitamin B-complex) having 4 replication and comprising one pair in each replication. The effects of supplementation of vitamins and selenium on the growth and reproductive performance of indigenous pigeons were observed.

There were no significant differences ($P>0.05$) in the live weight and feed intake (FI) of pigeons among different treatment groups. However, numerically higher live weight (374g) at 23 weeks and improved FI (23.38g) per pigeon per day were found in the T_0 and T_2 groups, respectively compared to other groups. Significant differences ($P<0.05$) were found for LWG and growth rate of pigeons and the highest results were obtained in the T_3 group (87.75g and 34.23%) which was treated with vitamins A, D, E, Se and vitamin B-complex. As a result, it was clear that selenium and all vitamins had a comparatively greater impact on the pigeons' growth performances.

Egg production and egg weight showed non-significant differences ($P>0.05$) among the treatment groups. The highest egg production was found in the T_3 group (11) and the lowest result was in the T_2 group (9). Increased egg weight was noticed in the T_1 (17.47g) and lower egg weight in the T_0 (16.90g) group. On the other hand, the shape index (SI) displayed significant differences ($P<0.05$) among other supplemented groups. The highest SI (%) was noticed in the T_3 (76.69) group and then followed by the T_1 (74.71), T_2 (73.07) and T_0 (71.70) groups. These results concluded that vitamins A, D, E, selenium and B-complex had a beneficial impact on the egg production of pigeons. The average percentage of hatchability and hatch did not show any significant difference ($P>0.05$) for each treatment. But numerically the highest hatches were observed in the T_3 group and hatchability was highest in the T_2 group. According to these results, vitamins and selenium boost pigeon hatchability and hatch percentage.

The squab performance parameters, day-old weight, weekly live weight, weekly live weight gain and weekly growth rate were measured. There was no significant difference (P>0.05) observed for the day-old weight of the squab. However, day-old weights of squab in various treatment groups were 10.89, 11.10, 11.04 and 11.14g for the T_0, T_1, T_2 and T_3 groups, respectively. Different treatment groups revealed significant differences (P<0.05) in weekly live weight, live weight gain and weekly growth rate of squab due to different supplementation. Significantly (P<0.05) higher live weight in the first week was found in the T_3 (159.35g) and the lowest weight in the T_2 (135.58g) group. Live weight in the second week showed no significant differences (P>0.05) but the highest weight was found in the T_3 group (218.34g) and then followed by T_0 (212.39g), T_1 (207.83g) and T_2 (196.25g) groups, respectively. On the other hand, in the third week, T_0, T_1, T_2 and T_3 presented significant differences (P<0.05) for the live weight of the squab, and the highest weight was seen in the T_3 group (274.05g) and the lowest weight in T_2 group (252.85g). In the case of weekly live weight gain, a significant difference (P<0.05) was observed in the first week, and no significant differences (P>0.05) were found for the second and third weeks of squab. The weekly growth rate percentage of squab was also recorded which was significant (P<0.05) only in the first week. The highest growth rate was noticed in the first week and then followed by the second and third weeks of age. At 21 day of age, squabs were slaughtered by halal method to evaluate the dressed weight (DW) and dressing percentage (DP) of squabs in different treatment groups. DW and DP showed significant differences (P<0.05) among the treatments and the highest DW and DP were found in vitamins A, D, E, Se and B-complex treated T_3 group compared to other groups. However, there was certainly no nutritional influence on the survivability of indigenous pigeon squabs. The FCR of squab did not differ significantly (P>0.05) in the various treatment groups. However, the T_3 group was found to have a better FCR than the other groups. This demonstrated that selenium and vitamins had a comparatively superior impact on the growth performances of squab.

Based on analysis of the above-mentioned research findings, it can be concluded that vitamins A, D, E, Se and B-complex supplementation had a very effective impact on the growth and reproductive performance of indigenous Gola pigeons. It can minimize the FCR and increase egg production, hatchability and dressing percentage. As a result, the current study advises using these formulas in the field to produce commercial pigeons in a way that is secure and environmentally friendly for our health. Literally, it is recommended to slaughter squabs at 4 weeks, but here the findings reveal that Gola pigeons are suitable to slaughter at 2 to 3 weeks. However, further more experimental trials are required to assess the impact of these additives on the large scale of pigeon production.

CHAPTER VI

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CHAPTER VII

APPENDICES

Appendix I. Growth Performance of Indigenous Gola Pigeon at 12 to 23 week of age

Treatment	Replication	Initial live weight at 12 week (g/bird)	LW at 23 week (g/bird)	LWG at 12 to 23 week (g/bird)	Growth Rate (%)
T_0	R_1	287	354	67	23.34
	R_2	288	372	84	29.17
	R_3	328	417	89	27.13
	R_4	291	353	62	21.3
T_1	R_1	299	373	74	24.75
	R_2	261	338	77	29.5
	R_3	332	400	68	20.48
	R_4	274	324	50	18.25
T_2	R_1	257	337	80	31.13
	R_2	286	336	50	17.48
	R_3	285	333	48	16.84
	R_4	293	343	50	17.06
T_3	R_1	241	338	97	40.25
	R_2	282	365	83	29.43
	R_3	268	345	77	28.73
	R_4	244	338	94	38.52

T_0 = (Control), T_1 = (Basal diet + Vitamin A, D, E & Se), T_2 = (Basal diet + Vitamin B-complex), T_3 = (Basal diet + Vitamin A, D, E & Se + Vitamin B-complex), LW = Live weight, LWG = Live weight gain.

Appendix II. Average Feed Supply and Feed Intake/ Pigeon/ Day during Growth and Reproductive Period (within 9 month)

Treatment	Replication	FS/ pigeon/day (g)	FI/ pigeon/day (g)
T_0	R_1	38	22
	R_2	56	36
	R_3	56	34
	R_4	49	29
T_1	R_1	35	24
	R_2	45	29
	R_3	48	33
	R_4	44	30
T_2	R_1	38	26
	R_2	57	34
	R_3	38	29
	R_4	44	27
T_3	R_1	56	38
	R_2	55	36
	R_3	48	27
	R_4	31	24

T_0 = (Control), T_1 = (Basal diet + Vitamin A, D, E & Se), T_2 = (Basal diet + Vitamin B-complex), T_3 = (Basal diet + Vitamin A, D, E & Se + Vitamin B-complex), FS = Feed supply, FI = Feed intake.

Appendix III. Reproductive Performances of Native Gola Pigeon

Treatment	Replication	Egg production	Fertile egg (No.)	Hatch (No.)	Egg weight (g/egg)	Shape index (%)	Hatchability (%)	Hatch (%)
T_0	R_1	12	2	1	17.46	72.67	50	8.33
	R_2	10	8	6	17.21	71.1	75	60
	R_3	12	10	9	17.85	72.89	90	75
	R_4	8	6	5	15.06	70.13	83.33	62.5
T_1	R_1	12	2	1	18.83	75.67	50	8.33
	R_2	10	8	6	17.19	74.6	75	60
	R_3	8	6	5	17.34	74.89	83.33	62.5
	R_4	12	10	6	16.52	73.67	60	50
T_2	R_1	10	8	7	16.12	73.25	87.5	70
	R_2	8	6	6	17.25	72.97	100	75
	R_3	8	4	4	17.31	72.82	100	50
	R_4	10	4	3	17.35	73.25	75	30
T_3	R_1	10	10	8	16.57	75.7	80	80
	R_2	14	8	6	17.82	78.5	75	42.86
	R_3	10	6	6	16.31	74.77	100	60
	R_4	10	8	6	17.18	77.8	75	60

T_0 = (Control), T_1 = (Basal diet + Vitamin A, D, E & Se), T_2 = (Basal diet + Vitamin B-complex), T_3 = (Basal diet + Vitamin A, D, E & Se + Vitamin B-complex).

Appendix IV. Weekly Growth Rate (%) of Squab of Indigenous Gola Pigeon

Treatment	Replication	Average Body Weight (g)				Weekly Body Weight Gain (g)			Weekly growth rate (%)			TGR (%)
		Day old weight	1st week	2nd week	3rd week	1st week	2nd week	3rd week	1st week	2nd week	3rd week	
T_0	R_1	12	156	200	270	144	44	70	171.43	24.72	29.79	225.94
	R_2	11.15	166.48	235	274.17	155.33	68.52	39.17	174.88	34.13	15.39	224.4
	R_3	10.83	141.26	208.57	261.41	130.43	67.31	52.84	171.51	38.49	22.49	232.49
	R_4	9.57	161.07	206	246.58	151.5	44.93	40.58	177.57	24.48	17.93	219.98
T_1	R_1	12	160.3	210.45	270.34	148.3	50.15	59.89	172.14	27.05	24.91	224.1
	R_2	11.36	134.67	204.57	255.12	123.31	69.9	50.55	168.88	41.21	21.99	232.08
	R_3	10.67	139	226.29	268	128.33	87.29	41.71	171.48	47.79	16.88	236.15
	R_4	10.37	142	190	258.33	131.63	48	68.33	172.78	28.92	30.48	232.18
T_2	R_1	11.57	145	193.16	261.75	133.43	48.16	68.59	170.44	28.48	30.16	229.08
	R_2	11.78	127	188.82	251.52	115.22	61.82	62.7	166.05	39.15	28.48	233.68
	R_3	10.49	130	198	258.13	119.51	68	60.13	170.13	41.46	26.37	237.96
	R_4	10.33	140.3	205	240	129.97	64.7	35	172.57	37.47	15.73	225.77
T_3	R_1	10.49	148	213.35	270	137.51	65.35	56.65	173.53	36.17	23.44	233.14
	R_2	11.83	183.41	240	280.2	171.58	56.59	40.2	175.76	26.73	15.46	217.95
	R_3	10.78	155	215	265	144.22	60	50	173.99	32.43	20.83	227.25
	R_4	11.47	151	205	281	139.53	54	76	171.76	30.34	31.28	233.38

T_0 = (Control), T_1 = (Basal diet + Vitamin A, D, E & Se), T_2 = (Basal diet + Vitamin B-complex), T_3 = (Basal diet + Vitamin A, D, E & Se + Vitamin B-complex), TGR=Total growth rate.

Appendix V. Dressing Percentage, Feed Conversion Ratio (FCR) and Survivability of Squab of Native Gola Pigeon

Treatment	Replication	Average Body weight (wt.) (g)		DW (g)	DP (%)	LWG (g/bird)	Total feed consumption (FC) (g/bird)	FCR	Survivability (%)
		Day old wt.	3^{rd} week						
T_0	R_1	12	270	160	59.26	258	2022	7.84	100
	R_2	11.15	274.17	172	62.73	263.02	1422.83	5.41	100
	R_3	10.83	261.41	159.83	61.14	250.58	1191.5	4.75	89
	R_4	9.57	246.58	155.4	63.02	237.01	1192.5	5.03	80
T_1	R_1	12	270.34	165.66	61.28	258.34	1544	5.98	100
	R_2	11.36	255.12	154.41	60.52	243.76	1256.5	5.15	100
	R_3	10.67	268	159.12	59.37	257.33	1300.25	5.05	80
	R_4	10.37	258.33	150.56	58.28	247.96	1286.75	5.19	67
T_2	R_1	11.57	261.75	154.61	59.07	250.18	1114	4.45	86
	R_2	11.78	251.52	147.43	58.62	239.74	1177.83	4.91	100
	R_3	10.49	258.13	145.58	56.4	247.64	1325.5	5.35	100
	R_4	10.33	240	140.23	58.43	229.67	1033	4.5	67
T_3	R_1	10.49	270	166.19	61.55	259.51	1309.14	5.04	88
	R_2	11.83	280.2	176.73	63.07	268.37	1321.67	4.92	100
	R_3	10.78	265	163.23	61.6	254.22	967.5	3.81	100
	R_4	11.47	281	172.45	61.37	269.53	991.83	3.68	100

T_0 = (Control), T_1 = (Basal diet + Vitamin A, D, E & Se), T_2 = (Basal diet + Vitamin B-complex), T_3 = (Basal diet + Vitamin A, D, E & Se + Vitamin B-complex), DW=Dressed weight, DP=Dressing percentage, LWG=Live weight gain, FC=Feed consumption, FCR=Feed conversion ratio.

PLATES

Plate 1. Foot bath at the Entrance of the Shed

Plate 2. Marking of Pigeon Cages

Plate 3. Weighing of Adult Pigeons

Plate 4. Distribution of Pigeons in Different Treatment Groups

Plate 5. Purchase of Feeds from Local Market

Plate 6. Weighing of Feeds

Plate 7. Supply Feeds to Pigeons

Plate 8. Weighing and Incubation of Hatching Eggs

 

Plate 9. Newly Hatched Squab and Brooding of Squab

Plate 10. Feeding of Squab

Plate 11. Weighing of Day-Old Squab

Plate 12. Growing Squab in the Nest

Plate 13. Slaughtering and Defeathering of Squab

Plate 14. Singeing and Removal of Organs of Squab

Plate 15. Weighing of Dressed Squab

Plate 16. Broken Egg, Dead Embryo inside the Egg, Dead Squab

Plate 17. Vaccination of Pigeon and Squab

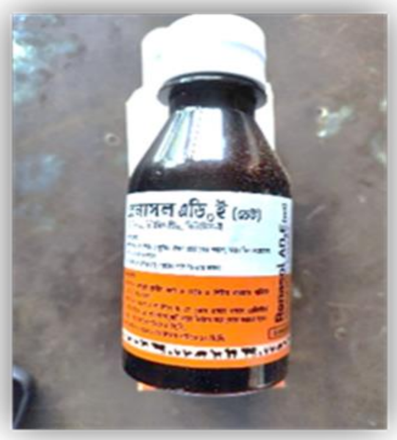

Plate 18. Medicines Used During the Research Period

Plate 19. Regular Farm Visit of Honorable Supervisor

Plate 20. Inspection of Pigeons with Respected Teachers