International Academic Research Consortium Journals (IARCJ)
International Journal of Agricultural Science and Technology
ISSN: 2360-9888. Volume 12, Issue 1
PP 131-143, July, 2024
DOI: 427251-452781-1222
arcnjournals@gmail.com
https://arcnjournals.org

HERITABILITY ESTIMATES OF GROWTH AND BODY WEIGHT CHANGES IN DOMESTIC PIGEONS (*Columba livia*) IN SEMI-ARID REGION OF NIGERIA

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Abstract*: The study was carried out to determined body weight of domestic pigeon squabs (Columba livia) and how they are affected by sex, shank colour and shank type and estimate their heritability at the Poultry unit of the Livestock Teaching and Research Farm of the Department of Animal Production Technology, Ramat Polytechnic Maiduguri, Borno State. A total of 50 pairs of parent pigeon were used to produce 428 squabs for the experiment. The birds were managed in monogamous pairs and fed with seeds, grains and crushed groundnut, with clean drinking water ad-libitum in a group or combined feeding system. The data collected from the squabs were weights at hatch and at intervals of three days to 30 days. All the data were analysed using the General Linear Model (GLM) procedure of SAS computer package while the means were separated using Duncans Multiple Range Test. Heritability was estimated using the Mixed Model Maximum Likelihood Method. The results showed that the domestic pigeon squabs do exhibit a sexual dimorphism with the male squabs recording significantly (P<0.05) higher body weights at all ages. Pigeon squabs with intermediate red shank colour were significantly heavier (P<0.05) at all the ages. The estimates of heritability of body weight of domestic pigeon squabs were high and ranged from 0.48 to 0.99 from day old to 30 days of age. The heritability estimates increase with increased in age which indicates that selection for improvement of body weight can be achieved.*

Keywords: *Body Weight, Pigeon Squabs, Heritability, Shank Colour, Shank Type.*

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DESCRIPTION OF PROBLEM

In Nigeria, poultry contributes significantly to the animal protein supply of the populace. The poultry population was put at 114.3 million comprising of 82.4 million chickens (11% of which was commercially raised) and 31.9 million other poultry which include pigeons, ducks, guinea fowls and turkeys (RIM, 1992). Pigeons have been one of man's closest associates for more than 4,000 years. They perform many useful functions and have many qualities that make them useful for laboratory and research purposes (Bennett, 2008). Some of the varieties have been selected for fancy colours and interesting forms. Others have been selected for their endurance and homing instinct (Bennett, 2008). Pigeons readily adapt themselves to living under a variety of conditions. Their diets is simple and are easily tamed, are normally free from objectionable odours and the noises made by them are not loud or harsh. Therefore, it is an easy matter to keep pigeons in cities, towns or other urban locations (Janssens *et al.,* 2002). Pigeons require little space and can be obtained at reasonable cost. For these reasons pigeons enjoy considerable popularity among persons of all ages and walks of life (Pigeons control resource Centre, 2009).

The live body weight of any animal is an important variable that determines the market value of that animal. The exact time at which the animal is ready for slaughter can be assessed on the basis of its body weight and general development (Akanno and Ibe, 2006). Body weights are shown to be influenced by maternal effect or dominance effects or both, up to maturity as indicated by consistently higher heritability estimates from dam variance components as opposed to those from sire components (Adeyinka *et al.,* 2004).

Indigenous birds are a vital reservoir of gene resources and their conservation has a technical role related to the future development of the production system as well as a socio-cultural role (Camacho-Escobar *et al*., 2008). Although, precise measurements of the productivity and biometry of the rural poultry is often complicated by the effects of indiscriminate crossbreeding which has taken place between them and the exotic strains (Oluyemi, 1989). Chineke *et al.,* (2002) reported that the relationship existing among body characteristics provide useful information on performance, productivity and carcass characteristics of animals and that these quantitative measures of size and shape are necessary for estimating genetic parameters in animal breeding programmes. Genetic analyses of traits of economic importance in poultry have been used extensively in monitoring the genetic variability of each line, where the estimates of the genetic parameters are indispensable in establishing the selection programs (Grosso *et al*., 2010).

The estimation of genetic parameters is fundamental to quantify the magnitude of the variability and extension in which the desirable characters are inherited, in order to promote the planning and progress of an effective program of genetic improvement (Vencovsky and Barriga, 1992). Genetic parameters, such as heritability and genetic correlation are the most important consideration in determining appropriate animal evaluation methods. Crucial to the accuracy of breeding value and genetic parameter estimations is the availability of record and structure of the data (Nurgiartiningsih *et al*., 2005). Knowing the degree of association between the characters is extremely valuable for the improvement strategies since it clarifies and quantifies the relationship between them, mainly when the selection of a character promotes changes in other correlated traits (Ramalho *et al.,* 2008). Effective selection necessarily includes the prediction of genetic values of the traits involved and might be obtained by estimating the components of the genetic and phenotypic variance (Cruz *et al.,* 2004). The genetic parameters would influence breeders' decision on the selection methods to be employed to achieve rapid genetic progress (Chineke and Adeyemi 2001).

MATERIALS AND METHODS

Experimental Site

The study will be conducted at the Poultry and Livestock Teaching and Research Farm of the Department of Animal Production Technology, Ramat Polytechnic Maiduguri of Borno State, Nigeria. Maiduguri the capital city of Borno State is located at latitude 11^0 51'North and longitude

13^0 05' East and at an altitude of 354 m above sea level. Maiduguri has very short duration of rainy season (3-4 months) with about 645.9 mm/annum and a long dry season of about 8-9 months (MCN, 2018). The ambient temperature could be as low as 20° C during the dry cold season in December - January and as high as 44° C during the dry hot season in April and May. Relative humidity is 45% in August which usually lowers to about 5% in December and January. Day length also varies from 11 to 12 hours (Aliyu *et al.,* 2013).

Experimental Animals and their Managements

A total of 200 pairs of parent's pigeon will be used to produce 800 squabs at 4 parities by each parent pair of pigeon for the experiment. The birds will be housed in shelters provided for protection against predators and harsh weather conditions in an intensive system. The parent pigeons of breeding age will be housed in wooden cage attached externally to the walls (open house type) usually in monogamous pairs or couples. They will be fed with seeds and grains, varying from wheat, millet, sorghum to crushed maize and kitchen scraps, two to four times daily. Clean drinking water will be provided *ad-libitum.*

Data Collection

Using a 5000 g digital sensitive weighing scale, measurements on body weights will be individually collected at different intervals at hatch, 3, 7, 10, 14, 18, 21, 24, 27 and 30 days. Data will be collected both from the parents and the offspring. Pigeon normally lay two eggs about 40 hours apart, each egg will be given unique number (A for the first and B for the second in order of time of lay), eggs weight will be taken. The information to be collected from the parents are; plumage colour, shank type, shank colour, while the data to be collected from the offsprings are; weight at hatch, 3, 7, 10, 14, 18, 21, 24, 27and 30 days. Plumage colour, shank type, and shank colour of the offspring will be recorded and kept.

Statistical analysis

The Data collected will be subjected to analysis of variance (ANOVA) using General Linear Models Procedure of SAS (version 9.0) to compute means (±standard errors), coefficient of variance and variance components using the variance component procedure (PROC VARCOMP). $Y_{ijkl} = \mu + S_i + D_j + e_{ijkl}$

Where Y_{ijkl} = Single observation.

μ = population mean

S_j = (effect of sire (i = 1, 2, …….n)

D_j = (effect of dam (k = 1, 2, ……n)

e_{ijkl} = residual random error

Heritability

The heritability (h^2) of growth and body weight characteristics will be estimated using the inter class correlation method i.e sire and dam variance component according to Becker (1985). From sire variance components: $h^2 = \frac{4(\delta^2 s)}{\delta^2 s+\delta^2 D+\delta^2 W}$

From dam variance components: $h^2 = \frac{4(\delta^2 D)}{\delta^2 s+\delta^2 D+\delta^2 W}$

From sire and dam variance components: $h^2 = \frac{2(\delta^2 s+\delta^2 D)}{\delta^2 s+\delta^2 D+\delta^2 W}$

Where: $\delta^2 s$ = the variance component for sire
$\delta^2 D$ = the variance component for dam
$\delta^2 W$ = the error variance component

Standard error (S.E) for heritability estimates will be approximated following the method of Dickerson (1969):

$$\text{S.E. }(h^2) = \sqrt{\frac{\frac{2}{k_3^2}\left(\frac{ms^2 s}{s-1}+\frac{ms^2 D}{d-s}\right)}{4\delta^2 T}}$$

$$\text{S.E. }(h^2) = \sqrt{\frac{\frac{2}{k_1^2}\left(\frac{ms^2 s}{D-S}+\frac{ms^2 E}{d-s}\right)}{4\delta^2 T}}$$

$$\text{S.E. }(h^2) = \sqrt{\frac{\frac{2}{k_2^2}\left(\frac{ms^2 s}{s-1+2}+\frac{ms^2 D}{d-s+2}\right)}{4\delta^2 T}}$$

Where: MS_S = Mean square of sire, MS_D = Mean square of dam, $\delta^2 T$ = Total variance S = number of sire, D = number of dam, K_1 = number progeny per dam within sire K_2 = number progeny per dam, K_3 = number progeny per sire

The coefficients of K_1, K_2 and K_3 will be determined by following formulae below:

$$K_1 = \left(n.. - \sum_i \frac{\sum n^2 ij}{ni.}\right)/d.f \text{ (dams)}$$
$$K_2 = \left(\frac{\sum i \sum_i n^2 ij}{ni.} - \frac{\sum i \sum_i n^2 ij}{n..}\right)/d.f \text{ (sires)}$$
$$K_3 = \left(n.. - \sum_i \frac{n^2 i.}{ni..}\right)/d.f \text{ (sires)}$$

RESULTS AND DISCUSSION

Effect of sex, shank colour and shank type on body weight of domestic pigeon squabs at different ages

The effect of sex on body weights of pigeon squabs at various ages are shown in Table 1. Sex had significant (P<0.05) effect on body weights of domestic pigeon squabs at all ages. Males appear to have higher body weights than their female counterpart at all ages. This may indicate that there is sexual dimorphism in pigeons' body at all ages. This agrees with the report of Fajemilehin (2017) and Aliyu *et al.* (2017). Aliyu *et al.* (2017) who also reported that male squabs were significantly heavier (p<0.05) than their female counterparts in body weights at hatch, 7 through 28 days of age. The findings of Ibrahim and Akut (2007) also reported significantly heavier males than females at all ages. Ridho *et al*. (2021) also reported significant sex variation of body weight in

Ecotype Fulani chickens from day old to 20 weeks of age. The mean body weights ranged between 15.53 to 386.60 g in males and 14.84 to 370.53 g in females. In similar vein, Bhowmik *et al.* (2014) reported in Jalali pigeons at 3-day to 5-month of age as 37.19 to 339.40 g, for males and 26.16 to 310.19 g, for females. The mean values of body weights in this study were higher than those of Raji *et al.* (2017) who reported the mean body weights of domestic pigeon squabs at hatch to 28 days of age as 13.51 to 325.14 g for males and 12.73 to 313.45 g for females, respectively with no significant sex effect observed.

The effects of shank type on body weight of indigenous pigeon squabs are presented in Table 1. Two different shank types were recorded in the domestic pigeon population during the period of the study. These are; Unfeathered (64.1%) and Feathered (35.9%). The result shows that squabs with unfeathered shank type appeared to be heavier in body weight than the feathered shank squabs at all ages but no significant difference (P>0.05) in body weight at all ages among the pigeon squabs. The result of this study is in line with those of Ndiilokelwa (2011) who observed similarities in feathered and non-feathered shank in local chickens. However, variation in body weights with shank type appears to be haphazard showing no particular trend, that is, no shank type was out rightly superior to other in all ages of pigeon squabs. Thus, the feathered and unfeathered shank type had a similar genetic basis for their formation and is apparent from the activity of many of the same genes in the development of the both shank type. Indeed, shank type can quite readily switch to producing feathers rather than unfeathered shank, as seen in many of species of domesticated birds with feathered shank (Delker, 2015).

The effect of shank colour on body weight of pigeon squabs are presented in Table 1. Three different shank colours were recorded in the domestic pigeon population during the period of the study. These are; Light red (34.64%), Intermediate red (62.35%), and Dark red (3.01%). Pervez *et al.* (2016) and Bhowmik *et al.* (2014) observed that the shank colour of Jalali pigeons were red. The result shows that squabs with intermediate red colour shank had generally highest body weight (P<0.05) at all ages than those with light and dark Red shank colours. Oguntunji and Ayorinde (2014) observed that shank colour had significant effect on body weight of Muscovy ducks is in line with the present findings. Furthermore, Foluke *et al.* (2020) reported that genes responsible for light pigmentations (white and ash plumage patterns) influences expression of yellow shank in Muscovy ducks while the gene responsible for black plumage pattern influences expression of black and slate/grey shank colours in Muscovy ducks which corroborates the findings of Nordskog (1970) who showed that not only shank colouration genes are responsible for shank colour but also the plumage genotype. The author further stated that shank colour of birds with dark plumage is black or slate or grey (melanin) and that of light plumage is yellow (non-melanin). Variations observed in shank colour in this study could be due to monogamous pairing nature of indigenous pigeons with no indiscriminate mating among the birds or might probably be attributed to genetic differences in the inheritance of shank colour in this species.

Body Weights Gains of Domestic Pigeon Squabs at Different Ages

The mean for body weights gains of pigeon squabs at various ages are shown in Figure1. The gain from day old to 30 days 15.51, 46.35, 64.83, 61.53, 61.40, 47.20, 4.21, 20.68, 19.49 and 22.45 g, respectively. The result is similar to the mean body weight gain reported by Is-haq (2019) who reported weekly gains from 1, 2, 3 and 4 weeks as 134.666, 66.786, 43.274 and 4.286g, respectively. Ashraful, (2013) also reported that the mean body weight gain of Jalali pigeon in India at 3, 15 and 30 days of age were 31.68, 193.85 and 225.53 g, respectively. It was evident that the mean body weights of pigeon squabs remarkably increased as the squabs advanced in age up to 14 days and begin to slow down gradually thereafter. Squabs have a faster rate of relative growth (0.1466 to 0.1945 g/d) compared to other domesticated poultry species such as chicken (0.0450g/d) and quail (0.077 to 0.097 g/d) as reported by Sales (2003).This is probably achieved by regurgitation of a white, slimy, caseous material formed by the desquamation of the epithelial cell structure in the parent for nutrition of the young. Its formation is controlled by prolactin. As a food of young pigeon, the crop milk consists of 75% water, 12.5% protein, 2.5% non-protein, 8.5% lipid and 1.5% minerals (Is-haq2019). In addition, it contains all the essential amino acids, fatty acids and gamma globulins, vitamins, mineral and trace minerals. Carbohydrates are present only in small amount. Crop milk is essential for squab and cannot be replaced by other material, at least not during the first six days of life. Both male and female pigeons (*Columba livia*) possess the ability to produce the complete nutrient substance for the nourishment of their young (Mohammed *et al.,* 2014).

The mean for body weights gains of pigeon squabs at various ages by sex are shown in Figure 2. Pigeon squabs had faster growth rate for both male and female but the rate slows down with age from 18 to 30 days. In all, overall weight gains of male squab were higher than female squab. Is-haq (2019) reported higher weight gain for than female pigeon squabs from day old to 4 weeks of age. Faraji Arough *et al*. (2019) reported variation of weight gains between male and female chicken from hatch to 20 weeks of age where male appear to have higher weight gain than their female counterpart. Similarly, Oguntade *et al*. (2020) reported weight gain from day old to ten weeks with the male consistently showing higher weight gain than the female chickens. The differences in body weight between sex could be attributed to more efficient feed conversation of the male than the female (Is-haq, 2019). Further factors in the sexual dimorphism could be attributed to sex hormones that is responsible for greater muscle development in males than females. In addition, all sexually dimorphic species, males appear to be larger in size and more conspicuous compared to their female counterparts. This may be ascribed to sex hormones which may promote larger muscle development in males than in females or could probably be attributed to hatching weights which male appear to have higher weight at hatch than females.

Heritability estimates of body weight and body measurements

Heritability estimates of body weight at different ages are presented in Table 2. The current estimates of heritability, which were generally high (0.48 to 0.99), could indicate the possibility to conduct a selection program to improve body weight in pigeon. Daikwo *et al.* (2017) reported Heritability estimates of body weight at Hatch weight, 1 week, 2week, 3 week, 4 week and mature bodyweight of 0.51, 0.24, 0.28, 0.33, 0.57, 0.44, 0.41 and 0.38 respectively. Heritability estimates for body weight at 1-week and 4-week of age were similar to the estimates reported by (Aggrey and Cheng 1992). Mignon-Grasteau *et al.* (2000) reported heritability of Body Weight at Week 4 for three different lines of pigeon were 0.53, 0.46 and 0.60 respectively. Similarly, Momoh *et al.* (2013) also reported the heritability estimates of body weights at hatch (0.52) and matured age (0.46). Adeyinka *et al.* (2004) reported moderate heritability for body weights of naked neck broilers at various ages, but observed high heritability estimates for body weight at 56 days of age and finally suggested that selection for body weight at this age will improve body weight in subsequent generations. Narinc *et al.* (2013) reported heritability of body weight of Japanese quail at 5 weeks of age was 0.36. Manjula *et al.* (2018) reported heritability estimates for body weight of Korean native chicken population were 0.458, 0.266, 0.161, 0.233, 0.088, 0.058, 0.042 and 0.128.

Increasing heritability estimates with age advanced observed in this study is line with report of Ahmed *et al.* (2022). Similar observation was noted by Momoh *et al.* (2013) in pigeon. However, this observation is contrary to the findings of Saatci *et al.* (2002), Daikwo (2011) in Japanese quails and Manjula *et al.* (2018) in the Korean native chicken population that heritability estimates of body weight traits exhibited a decreasing trend with increasing age. The differences in heritability values could be as a result of different populations and methods of computation applied in their studies. The high heritability with low standard error estimates of body weight obtained in this study indicated that improvement in these traits could be rapid using mass selection procedures. Peters (2000) reported that the amount of genetic variance in any population is largely a function of the level of selection that has taken place in that particular population as selection depletes additive genetic variance. Inbreeding as a mating system also reduces genetic variance. Increase in genetic variance reduces environmental variance with a consequential effect on numerical values of heritability (Getabalar *et al*., 2019). The high heritability at all ages in present study indicates that there is high genetic variability relative to phenotypic variability among the domestic pigeon squabs and selection for trait of interest may result in any appreciable improvement.

Table 1: Mean ± SE of body weights (g) by sex, shank colour and shank type of pigeon squabs

	SEX		SHANK COLOUR			SHANK TYPE	
Age (Days)	Male	Female	Light Red	Intermediate Red	Dark Red	Feathered	Unfeathered
0	17.10 ±0.39^a	13.92±0.35^b	15.43±0.16^a	15.64±0.12^a	14.26±0.51^b	14.256 ±0.35	14.498±0.42
3	67.80±1.97^a	55.92±1.89^b	57.85±0.81^b	64.19±0.61^a	55.87±2.66^b	58.112±1.77	59.734±2.13
7	134.96±4.15^a	118.42±3.98^b	120.46±1.60^b	131.26±1.21^a	114.22±5.29^b	117.00±3.73	121.94±4.50
10	199.11±5.77^a	177.33±5.54^b	180.56±2.32	185.00±1.75	193.90±7.67	175.57±5,19	182.14±6.25
14	264.28±7.39^a	234.96±7.08^b	239.71±2.83^b	256.73±2.13^a	235.35±9.34^b	231.48±6,64	237.26±8.00
18	332.78±8.80^a	260.86±8.44^b	284.27±3.34^b	305.03±2.51^a	285.00±11.00^b	265.24±7.91	270.84±9.53
21	314.30±8.08^a	287.74±8.75^b	288.60±3.14^b	309.83±2.37^a	290.13±10.37^b	282.56±7.26	291.24±8.75
24	332.94±7.95^a	310.48±7.85^b	309.77±3.15^b	330.54±2.37^a	313.09±10.39^b	304.69±7.36	311.30±8.88
27	360.16±7.85^a	322.22±7.59^b	329.60±3.12^b	350.15±2.35^a	330.52±10.29^b	320.82±7.85	328.89±8.57
30	386.07±7.59^a	341.21±7.22^b	354.30±3.12^b	371.57±2.35^a	354.00±10.28^b	343.21±6.82	350.16±8.22

SE= Standard error *ab= means within a row subset bearing different superscripts are statistically significant (p<0.05).*

Table 2: Heritability estimate ± SE of body weights (g) of domestic pigeon squabs at different Age.

Age (Days)	h^2	S.E (±)
0	0.48	0.11
3	0.78	0.11
7	0.99	0.03
10	0.99	0.03
14	0.99	0.03
18	0.99	0.03
21	0.99	0.03
24	0.99	0.03
27	0.99	0.03
30	0.99	0.03

SE= Standard error h^2= Heritability

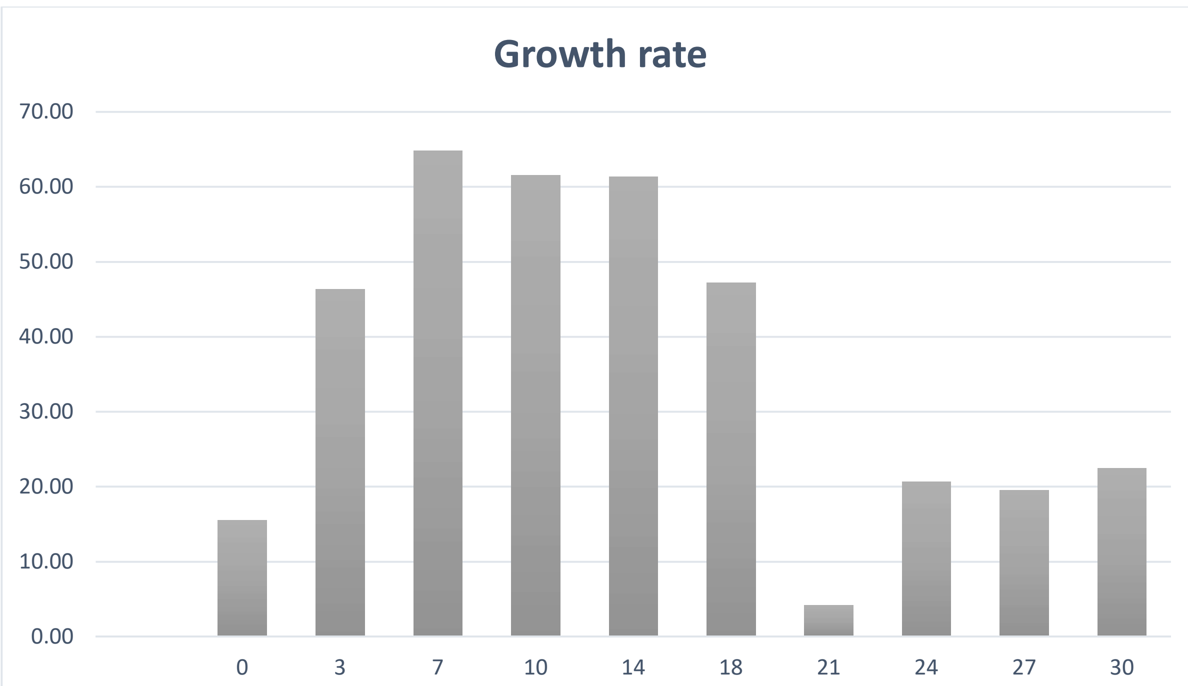

Figure 1: A bar graph showing the growth rate of squabs at different ages (g/days)

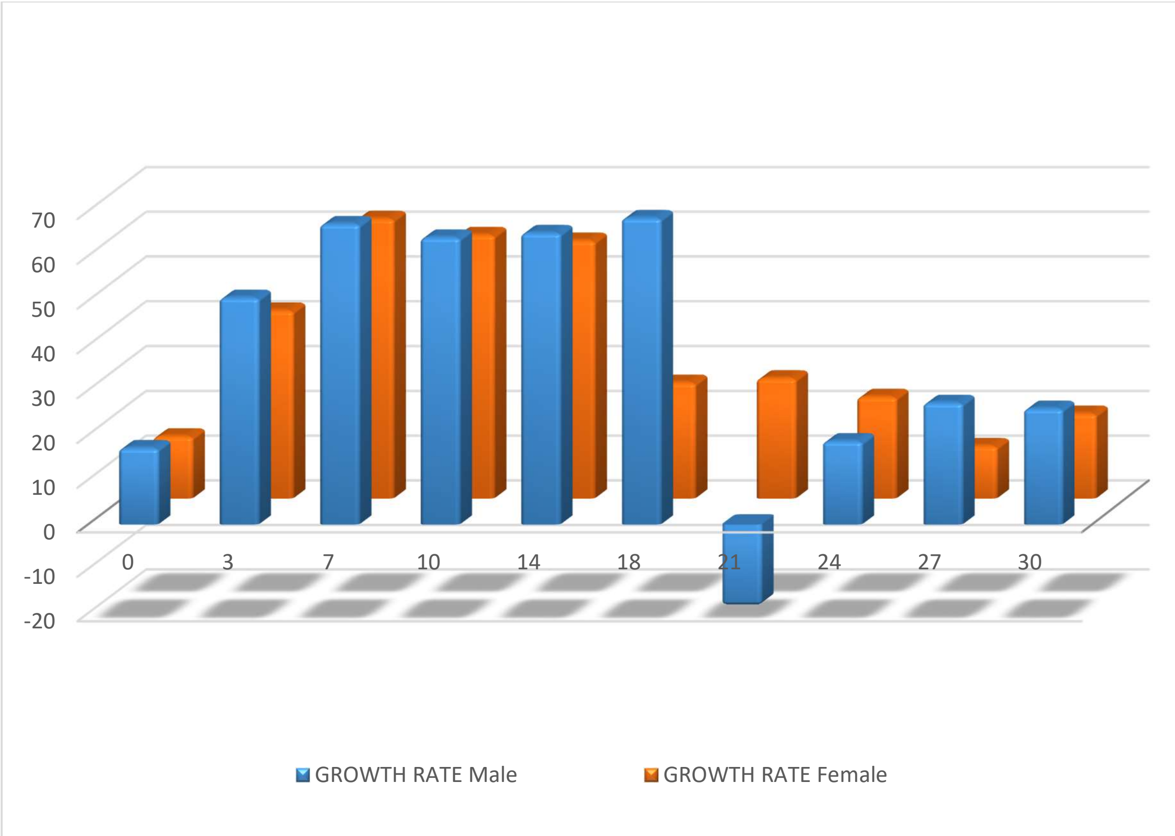

Figure 2: A bar graph showing the growth rate of squabs at different ages by sex (g/days)

Conclusion

The sexual dimorphism which was in favour of males was noticed at all ages for body weight of the domestic pigeon squabs. There was a shank colour variation on body weight of domestic pigeon squabs at all ages but variation in body weights with shank type appears to be haphazard showing no particular trend. Heritability estimates of growth traits were high at all stage of growth and increases with increase in age.

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