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Morphometric characteristics and carcass yield of composite rabbits as influenced by sex and housing system in Semi-Arid zone Nigeria

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Abstract
This study was conducted at Micro-livestock Unit Animal Science Teaching and Research farm, Federal University Dutsinma. Composites rabbits, comprising of both sexes, were raised in floor and cage systems of management. Data were collected on Twenty-four (24) adult rabbits randomly sampled to determine the effects of sex and rearing systems on body measurements and carcass traits. Data collected were subjected to statistical analysis. Results obtained on effect on linear body measurements showed that Rearing method had significant (P<0.05) effect on body weight and hind-leg length, but showed no significant effect on the BL, HG, AC, EL, TL, and FL. Values for cage were consistently higher than the floor. Then Sex had significant (P<0.05) effect on abdominal circumference, but showed no significant (P>0.05) effect on the BWT, BL, HG, EL, TL, FL and HL. Values for female rabbits were consistently higher than the males, except in EL were they have almost equal values (10.38 for female and 10.32 for male). There was no significant effects on the non-carcass traits measured in rearing except head and stomach that was significantly (P<0.05) affected and Sex had significant (P<0.05) effect on kidney and intestine, but showed no significant effect on the liver, lungs, heart, stomach, head, and skin. Rearing systems had significant (P<0.05) effects on all the carcass traits measured. Sex had no significant (P>0.05) effect on all the carcass traits measured. The result of phenotypic correlation analysis implies that majority of linear body measurements are good determinants of body weight. The phenotypic correlations between BWT and other non-carcass measured implies that majority of the traits have positive relationship. Correlations values among carcass traits in composite rabbits were high and positive with the highest value recorded between HC and RUMP (r = 0.99) and the lowest between SHOULDER and RIB (r = 0.72). Finally PCA further explain 3 PCs that determine the major variable that contributed in animal development and implies that linear body parameters can be used to predict body weight as the body weight shown to be the predictor of the carcass traits and any sex could be used for rabbit meat production.

Keywords: Composite rabbits, rearing system, sex, body measurements, carcass traits, phenotypic correlation, principal component analysis

Introduction
Global malnutrition remains a critical public health challenge. The Food and Agriculture Organization [FAO] (2006) [12] estimated that approximately 854 million people, representing 12.6% of the global population, were severely undernourished. Addressing this gap requires the exploration of alternative and sustainable animal protein sources that are suitable for small-scale farmers (Biobaku & Ekpeyong, 1991) [3]. Among these alternatives, small livestock species such as rabbits offer considerable potential for integrated, subsistence farming systems in developing countries. Rabbits possess several advantageous biological traits, including high reproductive efficiency, short gestation length, early maturity, high prolificacy, and the ability to rebreed shortly after parturition, which contribute to a short generation interval (Cheeke, 1986; Lebas *et al.*, 1997; Iheukwumere & Okoli, 2002[6, 18, 24]; Effiong & Wogar, 2007).

Rabbit production is relatively simple and low-cost compared to other monogastric species. Rabbits efficiently convert forages, shrubs, and leafy materialsoften unsuitable for direct human consumptioninto high-quality animal protein. Additional advantages include their small body size, quiet nature, ease of management, and high reproductive rate as induced ovulators (Cheeke, 1986) [6].

Nutritionally, rabbit meat is characterized by high protein content and low levels of fat and cholesterol, making it a healthy and preferred meat product (Dalle Zotte, 2000) [8]. Carcass yield and meat quality are influenced by breed (Singh & Prasad, 2005) and management practices.

Table 1: Comparative advantage of rabbit meat over other domestic livestock

	Protein%	Fat%	Moisture%	Energy (calories)
Rabbit	20.8	10.2	67.8	795
Chicken	20.0	11.0	37.6	810
Veal	19.1	12.0	68.0	840
Beef	16.3	28.0	55.0	1440
Pork	11.9	45.0	42.0	2050
Lamb	16.7	27.7	55.8	1420

Source: Lane, (1999) [23]

Description of Problem
The knowledge related to the variation of morphometric traits in the existing genetic resourses is most significant for the characterization of livestock including non-ruminant Animals such as rabbit, poultry and pigs (Delgado et al., 2001). Body weight and conformation are important factors for assessing growth in livestock since they have been proven to be useful in comparing size, shape of Animals (Amao, 2019). Body weight has been generally used to quantify body size and the association prevailing among linear body traits to give potential information on performance, productivity and carcass traits of farm

Animals (Chineke, 2001). A body measurement differs according to several factors which include: breed, yield type, sex and age. The biological relationship prevailing between the linear body traits may be different if the body measurement are extracted as multivariate fairly than bivariate, since body dimension are interconnected phenotypically and genetically (El-Mahdy, 1998).

Rabbit production has been promoted across sub-Saharan Africa as a viable strategy to bridge the protein deficit and improve food security, particularly among resource-poor households (FAO, 2006) [12]. Despite their high reproductive rate, short generation interval, and ability to convert forages and agro-industrial by-products into quality meat, the contribution of rabbits to animal protein supply in Nigeria remains marginal (Biaboku & Ekpeyong, 1991; Cheeke, 1986) [3, 6]. One major constraint is the lack of systematic information on how management practices and animal factors influence growth performance and carcass yield of the composite or unimproved rabbits that constitute the bulk of the national flock (Lebas *et al*., 1997; Ieukwumere & Okoli, 2002) [18, 24]

In Nigeria, rabbits are reared under diverse housing systems, ranging from conventional wire cages to deep-litter floor pens. These systems differ in space availability, stocking density, activity level, and exposure to environmental stressors, all of which can alter nutrient utilization, skeletal development, and fat deposition (Dal Bosco *et al*., 2002) [7]. However, most producers adopt housing methods based on tradition or convenience rather than evidence-based recommendations. Similarly, sex is known to affect growth rate, muscle deposition.etc.

Carcass and meat quality are primary criteria for evaluating rabbit meat production. Carcass quality must satisfy economic objectives such as high saleable meat yield and consumer acceptability (Dalle Zotte *et al*., 2002) [9]. Previous studies have demonstrated that both sex (Ozimba & Lukefahr, 1991) and rearing systems (Dal Bosco *et al*., 2002) [7] significantly influence body weight, carcass parameters, and meat quality in rabbits. However, limited information exists on the combined effects of sex and rearing system on body measurements and carcass traits of composite rabbits under Nigerian conditions.

The absence of reliable data on the interaction between sex and housing system creates uncertainty for farmers and extension agents in selecting animals for slaughter and breeding. Consequently, selection is often based on visual appraisal, which is subjective and prone to error. Therefore, there is a critical need to generate empirical evidence on how sex and housing system affect body measurements and carcass traits, and to identify the morphometric variables most strongly associated with carcass yield. Such information will support data-driven decision-making, enhance productivity, and contribute to sustainable rabbit meat production in semi-arid regions of Nigeria (Postollec *et al*., 2008; Khalid, 2011) [13, 22].

Justification

Rabbit production can help address protein deficiency in Nigeria, but low productivity persists due to limited data on how housing system and sex affect composite rabbits (FAO, 2018). Evidence shows housing influences carcass weight and meat quality, while sex affects growth and composition (Szendrő *et al*., 2018; Trocino *et al*., 2021; Zhang *et al*., 2024; Tavares *et al*., 2023). Without evidence-based guidelines, Nigerian farmers rely on subjective selection, reducing efficiency (Iyanda *et al*., 2023) [19]. This study is justified to provide empirical evidence for housing and sex management, and to identify morphometric predictors of carcass yield to support sustainable rabbit production in the tropics**.**

Aims and objectives of the study are evaluate the influence of sex and housing system on body measurements and carcass traits of composite rabbits, and to identify morphometric predictors of carcass yield for improved selection and management. The specific objectives are to determine the effect of sex and housing system on linear body measurements in composite rabbits. Assess the influence of sex and housing system on carcass yield and related traits. To establish correlations between body measurements and carcass traits. To Identify key morphometric variables using principal component analysis that can predict carcass yield in smallholder production systems. It was hypothesized that rearing system and sex would significantly influence body measurements and carcass traits, and that linear measurements would predict body weight and carcass yield.

Materials and Methods

The study was conducted at Micro-livestock unit, Prof. Abdu Lawal Saulawa Livestock Teaching and Research Farm, Federal University Dutsinma, Katsina State. Dutsinma lies within the coordinates of 12.45^0N latitude and 7.49^0E longitude and on altitude 605m above the sea level (Post Office, 2009). The average annual temperature ranges from 29^0C - 32^0C. The high temperature usually occurs between April to May and low temperature occurs between December through February. The vegetation of the area is sudan savanna, which constitute the characteristics and species of both the guinea and sahel savanna (Tukur, *et al*., 2013 and Rabiu, *et al*., 2013)

Experimental Animals

Composite, also referred to as non-descript rabbits resulting from crosses of breeds were used for this study. Composite rabbit stocks are products of non-specific crosses of breeds brought into sub-Saharan African countries which included, New Zealand White, California, Chinchilla, Checkered Giant among Others (Opoku and Lukefahr 1990).

Management of experimental Animals

Rabbits were randomly distributed into cage and floor system of rearing. They were fed with concentrates while vegetables and Forages were also given as supplements. Clean and cool water were supplied to the rabbit *ad libitum* throughout the experiment. Housing, feeding and health management followed standard rabbit production practices. The experiment lasted for 12 weeks. At the end of the research, Twenty-four (24) rabbits, comprising of equal male and female for both cage and floor rearing systems, were randomly sampled and used for this study as shown in Table 2

Table 2: Showing study sample size and distribution

	Rearing systems	
Sex	Cage	Floor
Bucks	6	6
Does	6	6
Total	**12**	**12**

Data Collection

Data were collected in two ways (*in vivo* parameters and *post mortem* parameters) from individual rabbits.

***In vivo* parameters which include:**

- Live body weight (LBW): Measured using weighing scale.
- Body length (BL): The dorsal distance between the base of the neck to the base of the tail/pin bone
- Chest girth (CG): Circumference measured around the chest at the centre of the right shoulder.
- Abdominal circumference (AC): Circumference measured around the abdomen at a specified point.
- Fore leg length (FL): Distance from the hock joint to the proximal end of the humorous.
- Hind leg length (HL): Distance from the base of femur to the end of tibia (cm)
- Ear length (EL): This was taken from the base of the ear to the tip.

All measurements are been taken according to the method described and adopted by Ogah *et al* (2012) [26].

Post mortem parameters

At 12 weeks of age all rabbits were weighed before slaughtering. Slaughtering is conducted by cutting the jugular veins and carotid arteries (Deltoro and Lopez, 1985). After the limbs and head were removed, each carcass was skinned, the abdomen opened, gut and internal organs removed. The weights of skin with head and limbs, liver, kidney, heart and lung were recorded. The carcass were further divided into four wholesale cut/primal cuts parts (fore-leg and shoulder, hind leg and rump, lion and rib and neck) according to Ashbrook (1955) [1]

These parameters are measured according to the procedure described by Blasco *et al*.(1993) [4].

Data Analysis

Data collected were subjected to statistical analysis using SPSS (2001) for descriptive statistics and correlation on linear body measurement, non-carcass variables and carcass variables.Duncan Multiple range Test was employed for comparing mean differences (Duncan, 1955) [10].

The model below was used;

$Y_{ijkl} = U + S_j + R_k + e_{ijk}$

Where:

Y_{ijkl} = Trait under study

U = Overall mean;

S_j = Fixed effect of j^{th} sex (j = male & female);

R_k = Random effect of k^{th} rearing method (k = Floor & Cage);

e_{ijkl} = Random error.

Principal Component Analysis (PCA) was utilized to identify the parameters that can best describe the carcass traits in rabbits, using PAST statistical package v 3.10.

Results and Discussion

Effect of Rearing Method on Linear Body Measurements

Table 3 shows the effect of the rearing method on linear body measurements in composite rabbits. The rearing method had a significant (P<0.05) impact on body weight (BWT) and hind leg length (HL). However, no significant effect was observed for body length (BL), heart girth (HG), abdominal circumference (AC), ear length (EL), tail length (TL), and fore leg length (FL). Rabbits reared in cages consistently exhibited higher mean values for BWT and HL compared to those on the floor. These findings might be attributed to the difference in locomotion and space availability between the two systems. The estimates obtained in this study were lower than those reported for exotic breeds (Karima *et al*., 2002; Okoro *et al*., 2004[21, 27]; Orheruata *et al*., 2006; Onyiro *et al*., 2008) [29], potentially due to the use of composite (non-descript) rabbits with generally lower genetic potential for growth compared to specialized meat breeds.

Table 3: Effect of rearing system on body measurements in composite rabbits

Traits	Rearing methods	Mean	SD	SE	Min	Max
BWT (g)	F	1.10^b	0.00	0.00	1.10	1.10
	C	1.35^a	0.10	0.04	1.20	1.50
BL (cm)	F	25.72	1.56	0.64	24.00	28.00
	C	27.17	0.98	0.40	26.00	28.50
HG (cm)	F	20,63	0.79	0.32	20.00	21.90
	C	20.37	1.55	0.63	18.00	22.20
AC (cm)	F	22.22	2.49	1.02	19.50	26.00
	C	22.28	1.28	0.52	20.30	23.80
EL (cm)	F	9.95	0.69	0.28	9.00	10.50
	C	10.75	0.70	0.29	9.50	11.50
TL (cm)	F	6.75	0.73	0.30	5.40	7.50
	C	7.23	0.67	0.27	6.50	8.00
FL (cm)	F	10.45	0.46	0.19	10.00	11.00
	C	10.73	0.60	0.25	9.90	11.50
HL (cm)	F	16.62^b	1.09	0.45	15.00	17.90
	C	18.35^a	0.94	0.38	17.00	19.40

F= Floor, C= Cage, BWT= Body weight, BL= Body length, HG= Heart girth, AC= Abdominal circumference, EL= Ear length, TL= Tail length, FL= Fore-leg length, HL= Hind-leg length, SD= Standard deviation, SE= Standard error. Superscript letters (a, b) denote significant differences (P>0.05)

Effect of Sex on Body Measurements

Table 4 indicates that sex significantly (P<0.05) influenced abdominal circumference (AC). No significant effect was found for body weight (BWT), body length (BL), heart girth (HG), ear length (EL), tail length (TL), fore leg length (FL), and hind leg length (HL). Female rabbits generally had higher mean values for most measurements compared to males, except for ear length, where values were similar. These findings suggest a degree of sexual dimorphism in specific body measurements within the composite rabbits, aligning with previous research (Ogah *et al*., 2006; Onyiro *et al*., 2008; Okoro *et al*., 2004) [27, 29].

Table 4: Effects of sex on body measurements in composite rabbits

Variables	Sex	Mean	SD	SE	Min	Max
BWT (g)	F	1.25	0.18	0.07	1.10	1.50
	M	1.20	0.13	0.05	1.10	1.40
BL (cm)	F	26.18	1.92	0.78	24.00	28.50
	M	26.70	0.91	0.37	25.50	28.00
HG (cm)	F	20.90	1.33	0.54	18.50	22.20
	M	20.10	0.97	0.40	18.50	21.50

AC (cm)	F	23.48^a	1.35	0.55	22.00	26.00
	M	21.02^b	1.54	0.63	19.50	23.80
EL (cm)	F	10.38	0.71	0.30	9.00	11.00
	M	10.32	0.92	0.38	9.20	11.50
TL (cm)	F	7.07	0.57	0.23	6.50	8.00
	M	6.92	0.88	0.36	5.40	8.00
FL (cm)	F	10.82	0.59	0.24	10.00	11.50
	M	10.37	0.40	0.16	9.90	11.00
HL(cm)	F	17.92	1.40	0.57	16.20	19.40
	M	17.05	1.21	0.50	15.00	18.50

F= Female, M= Male, SD= Standard deviation, SE= Standard error, BWT= Body weight, BL= Body length, HG= Heart girth, AC= Abdominal circumference, EL= Ear length, TL= Tail length, FL= Fore-leg length, HL= Hind-leg length. Superscript letters (a, b) denote significant differences (P>0.05)

Effect of rearing system on non-carcass traits

Table 5 revealed there were no significant effects on the non-carcass traits measured except head and stomach that was significantly (P<0.05) affected. The result also did not show any particular trend and were very near to the result reported by Ghosh and Mandal, (2008) [16] but lower than the findings of Al-Saef *et.al*

Table 5: Effects of rearing systems on non-carcass traits in composite rabbits.

Traits	Rearing methods	Mean	SD	SE	Min	Max
LIVER	F	33.67	7.47	3.05	25.90	47.90
	C	27.03	4.34	1.77	21.60	33.60
LUNGS	F	5.82	1.33	0.54	5.10	8.50
	C	7.98	2.96	1.21	5.50	13.50
KIDNEY	F	8.63	0.88	0.36	7.80	9.90
	C	7.77	1.57	0.64	6.20	10.20
HEART	F	2.72	0.35	0.14	2.30	3,30
	C	3.02	0.74	0.30	2.20	4.40
STOMACH	F	92.15^a	12.21	4.98	77.40	107.60
	C	53.55^b	6.64	2.71	41.00	60.00
INTESTINE	F	154.78	29.21	11.93	127.00	204.80
	C	128.17	22.66	9.25	100.00	159.00
HEAD	F	100.23^b	10.50	4.29	81.50	108.00
	C	116.67^a	7.63	3.12	104.00	126.00
SKIN	F	72.82	5.68	2.32	62.00	78.30
	C	82.50	13.71	5.60	60.00	99.00

F= floor, C= Cage, SD= Standard deviation, SE= Standard error. Superscript letters (a, b) denote significant differences (P>0.05)

Effect of Sex on Non-Carcass Traits

Table 6 revealed that sex had significant (P<0.05) effect on kidney & intestine, but showed no significant effect on the liver, lungs, heart, stomach, head & skin. Values for female rabbits were consistently higher than the males. The result obtained is lower than the result found by Ghosh and Mandal (2008) [16] & slightly agreed with the value reported by Khalid *et al* (2011) [22] & Yakubu *et al* (2007). This discrepancy may be due to the fact that kidney fat was weighted with the kidney in this study. And this confirms some levels of sexual dimorphism in the composite rabbits.

Table 6: Effect of sex on non-carcass traits in composite rabbits.

Traits	Sex	Mean	SD	SE	Min	Max
LIVER	F	34.08	7.25	2.96	26.60	47.90
	M	26.62	3.87	1.58	21.60	32.10
LUNGS	F	8.05	3.14	1.28	5.10	13.60
	M	5.75	0.55	0.23	5.20	6.70
KIDNEYS	F	8.92^a	1.18	0.48	7.20	10.20
	M	7.48^b	1.03	0.42	6.20	9.10
HEART	F	3.03	0.72	0.30	2.30	4.40
	M	2.70	0.36	0.15	2.20	3.30
STOMACH	F	76.15	21.89	8.94	56.00	107.60
	M	69.55	24.12	9.85	41.00	104.30
INTESTINE	F	161.53^a	24.58	10.03	135.00	204.80
	M	121.42^b	14.91	6.09	100.00	137.20
HEAD	F	108.02	17.57	7.17	81.50	126.00
	M	108.88	4.64	1.89	104.00	116.00
SKIN	F	81.87	13.18	5.38	62.00	99.00
	M	73.45	7.76	3.17	60.00	84.00

F= Female, M= Male, SD= Standard deviation, SE= Standard error. Superscript letters (a, b) denote significant differences (P>0.05)

Effect of Rearing System on Carcass Traits

Table 7 shown that rearing systems had significant (P<0.05) effects on all the carcass traits measured. Cage system was consistent higher than the floor rearing system. This shows that cage system of rearing is better than floor system. These observations might be related to the locomotory behaviour in rabbits reared in floor, e.g. the number of runs and jumps was 20% higher in large pens compared to the two other groups (Postollec *et al.*, 2008). These results are in accordance with previous studies that have reported the same link between increased locomotory behaviour and the above-mentioned carcass traits in rabbits reared in large pens compared to caged rabbits (Dal Bosco *et al.*, 2002; Jehl *et al.*, 2003) [7, 20]. Regarding the effect of rearing system, several studies reported a lower meat-to-bone ratio in floor housed rabbits compared to caged rabbits (Dal Bosco *et al.*, 2002; Jehl *et al.*, 2003[7, 20]; Dalle Zotte *et al.*, 2009)

Table 7: Effect of rearing systems on carcass traits in composite rabbits

Parameters/Traits	Rearing methods	Mean	SD	SE	Min	Max
HOT CARCASS	F	405.50^b	54.98	22.45	335.00	469.00
	C	577.50^a	94.10	38.42	446.00	708.00
SHOULDER	F	60.52^b	8.70	3.55	50.90	74.80
	C	74.17^a	5.81	2.37	66.00	80.00
RIB	F	95.30^b	19.99	8.16	73.70	117.00
	C	125.67^a	26.36	10.76	97.00	159.00
LOIN	F	128.32^b	20.42	8.34	94.40	146.40
	C	169.00^a	34.29	14.00	129.00	228.00
RUMP	F	114.97^b	14.98	6.11	93.20	133.60
	C	149.67^a	18.04	7.37	125.00	172.00

F= Floor, Cage= Cage, SD= Standard deviation, SE= Standard error. Superscript letters (a, b) denote significant differences (P>0.05)

Effect of Sex on Carcass Traits

Table 8 shows the effects on sex on carcass traits. Sex had no significant (P>0.05) effect on all the traits measured. Numerically, female had higher values than males. This also showed sexual dimorphism on carcass traits in the composite rabbits. The present finding was in line with the report of Khalid (2011) [22] found that the sex differences between males and females in carcass traits was non-significant for all carcass traits studied.

Table 8: Effects of sex on carcass traits in composite rabbits.

Parameters/Traits	Sex	Mean	SD	SE	Min	Max
HOT CARCASS	F	518.17	157.97	64.49	335.00	708.00
	M	464.83	54.46	22.23	399.00	533.00
SHOULDER	F	69.10	13.12	5.35	50.90	80.00
	M	65.58	6.48	2.65	57.50	76.00
RIB	F	115.98	37.65	15.37	73.70	159.00
	M	104.98	12.57	5.13	83.30	117.00
LOIN	F	155.95	48.43	19.77	94.40	228.00
	M	141.37	10.63	4.34	127.40	152.00
RUMP	F	137.30	33.15	13.53	93.20	172.00
	M	127.33	10.67	4.35	113.30	143.00

F= Female, M= Male, SD= Standard deviation, SE= Standard error. Superscript letters (a, b) denote significant differences (P>0.05)

Phenotypic Correlations among Linear Body Measurements

Table 9 showed the phenotypic correlations between BWT and other body measurements in composite rabbits. Highest phenotypic correlation value (r = 0.75) was recorded between BWT and HL while HG and HL has the lowest positive phenotypic correlation value (r = 0.03). The highest negative phenotypic correlation values was recorded between HG and EL (r = -0.44). The result of phenotypic correlation analysis implies that majority of linear body measurements are good determinants of body weight. That is, BWT could be predicted with greater accuracy using the values of majority of the body dimension. In agreement with this study, Ige *et al.* (2005) found linear body measurements are useful in live weight determination. The observed findings also presuppose that the growth in major body dimensions will in variable result to increase in live weight. Similarly, the positive, significant phenotypic correlations recorded among linear body measurements indicate strong relationship between the various traits that are connected with animal growth. According to El-ladan (1999) [23], positive relationships between these traits were as a result of pleiotrophic effect of genes and linkage effects which operate on these traits. Therefore, any attempt to perform phenotypic selection for one trait will consequently result in improvement of the other.

Table 9: Phenotypic correlations among some body measurements in composite rabbits.

Parameters	BWT	BL	HG	AC	EL	TL	FL	HL
BWT	1	0.52	-0.17	-0.04	0.58	0.52	0.50	0.75
BL		1	0.18	-0.14	0.12	0.06	0.72	0.67
HG			1	0.69	-0.44	-0.40	0.17	0.03
AC				1	-0.40	0.04	0.11	0.22
EL					1	0.07	0.16	0.24
TL						1	0.14	0.58
FL							1	0.71
HL								1

BWT= Body weight, BL= Body length, HG= Heart girth, AC= Abdominal circumference, EL= Ear length, TL= Tail length, FL= Fore-leg length, HL= Hind-leg length

Phenotypic Correlations among Non-Carcass Traits

Table 10 showed the phenotypic correlations between BWT and other body measurements in composite rabbits. Highest phenotypic correlation value (r = 0.79) was recorded between KN and LI while HT and LI has the lowest positive phenotypic correlation value (r = 0.01). The highest negative phenotypic correlation values was recorded between HT and HD (r = -0.76) While ST and HT has the lowest negative phenotypic correlation value (-0.17). This result was slightly agreed with the findings of Khalid *et al* (2011) [22] may be as a result of the environment and duration of the experiment, but they were much higher than the results reported by Umesh singh *et al* (2005) (0.36, 0.03) and Iraqi (2003) (0.57).

Table 10: Phenotypic correlations among non-carcass traits in composite rabbits

	LI	LU	KN	HT	ST	IN	HD	SK
LI	1	0.11	0.79	0.01	0.49	0.86	-0.25	0.16
LU		1	0.08	0.17	-0.42	0.20	0.52	0.61
KN			1	0.20	0.40	0.60	0.04	0.38
HT				1	-0.17	0.24	0.50	0.47
ST					1	0.50	-0.76	-0.40
IN						1	-0.26	0.07
HD							1	0.62
SK								1

LI= Liver, LU= Lungs, KN= Kidney, HT= Heart, ST= Stomach, IN= Intestine, HD= Head, SK= Skin.

Phenotypic Correlations among Carcass Traits

Table 11 shown the phenotypic correlations values among carcass traits. Values were high and positive with the highest value recorded between HC and RUMP (r = 0.99) and the lowest between SHOULDER and RIB (r = 0.72). This result agreed with the finding of Khalid *et al* (2011) [22] who also reported high positive relationship among carcass traits in matured rabbits.

Table 11: Showing phenotypic correlations among carcass traits.

Traits	HC	SHOULDER	RIB	LOIN	RUMP
HOT CARCASS	1	0.86	0.93	0.95	0.99
SHOULDER		1	0.72	0.77	0.89
RIB			1	0.92	0.92
LOIN				1	0.94
RUMP					1

Principal Component Analysis (PCA) on body measurements in composite rabbits

The results of the PCA revealed that seven principal components will explain the total variance in the body conformations (Table 12). Eigenvalue cut-off point 1.0 in table 12 showed that 3 PCs accounted for about 92.28% of the total variances. While the remaining PCs contributed about 7.72%. Each of the PCs 1 to 3 has eigenvalues above 1.0. PC 1 had total variances of 44.68%. Two traits with the highest loadings in PC 1 include HG and AC (0.45 and 0.86 respectively). Two highest loadings in PC 2 are 0.72 and 0.61 for BL and HL respectively, accounted for about 34.21 %. The third PC loadings accounted for 13.40% included BL, HG, TL and HL, contributing -0.44, -0.55, 0.48 and 0.42 respectively.

Table 12: Eigenvalues and the proportions of the total variances of the Principal Component Analysis (PCA)

PC	Eigenvalue	% variance	Cumulative
1	4.578	44.677	44.677
2	3.506	34.210	78.887
3	1.372	13.397	92.284
4	0.477	4.652	96.936
5	0.156	1.519	98.454
6	0.0953	0.931	99.385
7	0.0631	0.616	100.000

Table 13: Summary of the Principal component analysis (PCA)

	PC1	PC2	PC3	PC4	PC5	PC6	PC7
BL	0.0079	0.7203	-0.4411	-0.11895	-0.1868	0.4153	0.2550
HG	0.4454	-0.0031	-0.5479	0.1318	0.6457	0.2589	0.0035
AC	0.8623	-0.1181	0.2425	0.0879	-0.3101	-0.2447	0.1414
EL	-0.1625	0.1198	0.1919	0.8941	0.1548	-0.1577	0.27223
TL	-0.0025	0.1336	0.4782	-0.3915	0.4923	-0.0185	0.5978
FL	0.0524	0.2223	-0.0262	0.0808	-0.3970	0.8009	0.3763
HL	0.1702	0.6209	0.4245	0.0381	0.1674	0.1842	-0.5847

Conclusion and Recommendation

Sex had no significant effect on carcass traits, indicating that both males and females are suitable for meat production. Rearing system significantly influenced body weight, hindleg length, and all carcass traits, with cage systems performing better. Three principal components accounted for 92.28% of the variation in morphometric traits. It was r**ecommendation that:** Any sex can be used for rabbit meat production by the farmers meat since there was no significant different on sex with carcass traits.The best predictor between live body weight and linear body measurements is heart girth, body length and abdominal circumferences because they have high values than others.Rabbit farmers should be trained on proper measurements techniques**.** Further research should be conducted to determine the factors affecting rabbit carcass.

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