EFFECT OF SEX AND ENVIRONMENTAL PARAMETERS ON PERFORMANCE AND PHYSIOLOGY OF RABBIT

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ABSTRACT
The cramped conditions in which rabbits are housed in intensive breeding units have drawn criticism because it prevents them from exhibiting behaviours unique to their species. A research was done using a total of 40 weaner rabbits comprising of 20 of males (M) and 20 females (F) housed based on sex in galvanized battery cage hutches equipped with concrete feeders and drinkers and kept either indoor (I) or outdoor (O) for 56 days. The rabbit were grouped based on sex and housing system in a 2×2 factorial arrangement given rise to four treatments as follows: Treatment (T) 1: 10 MI, T 2: 10 F I, T 3: 10 M O, T 4: 10 F O. Growth performance, blood, body physiology and stress marker data was collected using standard procedures and subjected to analysis of variance in a completely randomized design using the SAS (2010) software package. Rabbits reared under the outdoor system had significantly ($P<0.05$) higher feed intake (4521.6g) than rabbits reared indoor (4184.9g). Rectal temperature, body temperature, haematological parameters were not significantly ($P>0.05$) influenced by sex and housing systems. Rabbits reared outdoor had significant ($P<0.05$) higher creatinine level (0.99 $mgdl^{-1}$) than those reared indoor (0.62 $mgdl^{-1}$). FO rabbits had a significantly ($P<0.05$) higher cortisol level (6.59 and 6.94) when compared with the cortisol level of their male counterpart (4.44 and 4.93). It was concluded that growth performance was not different between male and female rabbits while cortisol level of female rabbits reared outdoor are higher than male rabbits. It was recommended that rearing rabbit indoor housing reduces stressors.

Keyword: Housing, Rabbit, Sex, Stressor

1.0 INTRODUCTION

Global production of rabbit meat is expanding in order to meet the growing demand for a variety of meat products that will meet the dietary needs of the world's growing population. China is the world's greatest producer of rabbit meat, followed by Europe, with an annual production of roughly 1.4 million tons (FAOSTAT, 2020). According to Zotte (2002), rabbit meat has good sensory qualities; it is flavourful, lean, and soft with less fat than other meats like chicken and pork. It is also high in protein, unsaturated fatty acids, conjugated linoleic acid, and minerals, all easily digested by humans. According to Zotte and Szendroe (2011), meats are also high in polyamine, antioxidant vitamins, and selenium.

Due to their higher metabolic rates and production capabilities, rabbits are more vulnerable to environmental stressors such as intense farming, high temperatures, transportation, and changes in feed composition (Marai et al., 2011). Due to their thick villi and lack of sweat glands, rabbits are particularly vulnerable to the negative effects of high temperatures on their health and performance. In response to high temperatures outside, rabbits will extend their bodies to increase their body temperature through convection and radiation and by stretching their ear pinnae and spreading them apart to expose their surface to the environment (Nielsen *et al.*, 2020).

The confinement of animals in intensive breeding units has been challenged since the animals are housed in a constrained setting where they cannot conduct their species-specific behavioural features, such as locomotor movements (Sabry, 2021). Thus, comparing the performance of sexed rabbits raised in various housing systems was the goal of this study.

2.0 MATERIALS AND METHODS

Experimental location
The study was done at the Rabbit Unit of Federal Polytechnic IlaroTeaching and Research Farm, Ogun State, Nigeria. It has an altitude of 141m above sea level and coordinates latitude 6.895550°N and longitude 2.977167°E (GPS display, 2021).

Experimental Animals and Management

A total of 40 weaner rabbits comprising 20 males and 20 females were purchased from a reputable farm and used for this study. The animals were housed based on sex in galvanized battery cage hutches equipped with concrete feeders and drinkers and kept either indoors or outdoors. The indoor house was a standard rabbitry while the outdoor house roof was covered by polythene and palm frond, other locally available materials such as bamboo, rope, and nylon were also used. The experiment lasted for 56 days. Baseline blood samples were collected at the commencement of the experiment for haematological, serum and stress markers. Commercial feed and water were given *ad libitum*.

Experimental Design
The animals were housed either indoors or outdoors and were grouped based on sex in a 2×2 factorial arrangement giving rise to four treatments as follows:
Treatment 1: Male 10 rabbits reared indoor
Treatment 2: Female10 rabbits reared indoor
Treatment 3: Male10 rabbits reared outdoor
Treatment 4: Female10 rabbits reared outdoor
Each animal was housed in each cell in the hutch and house, serving as replicates.

Data collection
Each replicate of the rabbit was weighed at the start of the experiment and every week thereafter. The difference between the two weight readings represents the rabbits' weekly body weight gain. Each rabbit received a predetermined amount of feed, and the amount of feed left over was weighed to calculate the daily and, subsequently, weekly feed intake. By dividing the entire amount of feed consumed by the total amount of weight gained, the feed conversation ratio for each replicate was calculated.
Blood sample (5 ml) was collected from five rabbits per treatment at the beginning (1day) and toward end of the experiment (50th day) using syringes and needle into the tubes containing ethylene diamine tetra acetate (EDTA) as anticoagulant and sample bottles without anticoagulant for heamatological parameters (packed cell volume, red blood cell, heamoglobin and white blood cell as well as haematological indices mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH) and mean corpuscular haemoglobin concentration (MCHC) according to Davice and Lewis (1991) and serum biochemistry (total protein (TP), globulin,

albumin, urea, aspartate amino transferase, alanine amino transferase, and cholesterol) analysis.

Determination of Rabbit Body Physiology

Daily micro-environment data i.e. daily ambient temperature and relative humidity was taken at 6 hours, 14 hours and 20 hours using thermo hygrometer. The rectal and body temperature of all the animals was also taken at 6am (06hours) and 2pm (14hours) using the Kris Alloy digital thermometer. The thermometer was inserted into the rectum of each rabbit at approximately 4 cm for 1 minute after which the reading was taken. The body temperature was determined by inserting a digital thermometer into the armpit of the rabbit.

Determination of Stress Marker Profile of Rabbits

On the 1st day and 50th day of the experiment, blood samples were collected from the ear pinner of three rabbits per treatment. The blood sample in the tube of each rabbit was 20ul of cortisol standards, control and serum was added into the Streptavidin-coated micro-wells. 50ul of biotin reagent and 100ul of cortisol enzyme conjugate were also added to the wells thoroughly mixed for 10 seconds and incubated for 60 minutes. The liquid was removed from the resultant mixture and incubated again for 10 minutes at 25°C. Cortisol levels were recorded and cortisol standard value was checked on each vial.

Statistical analysis

The SAS (2010) software package was utilized to arrange all the data in a 2 × 2 factorial configuration and then subject it to Analysis of Variance in a Completely Randomized Design. Significant variations among treatment means were isolated using the Duncan multiple range test as supplied in the software. The estimations of the Pearson correlation between the physiological parameters and body weight of male and female rabbits housed in indoor and outdoor environments were obtained using the same software program.

Statistical Model

$\mathbf{Y_{ijk}} = \mu + A_i + B_j + (AB)_{ij} + \Sigma_{ijk}$

Where:

$\mathbf{Y_{ijk}}$= Individual k^{th} observation on i^{th} effect of sex and j^{th} of housing systems

$\boldsymbol{\mu}$ = Overall Mean

$\mathbf{A_i}$= fixed effect of i^{th} sex (male and female)

$\mathbf{B_j}$ = fixed effect of j^{th}Housing system (indoor and outdoor)

$\mathbf{(AB)_{ij}}$ =fixed effect of interaction between sex and housing system

$\boldsymbol{\Sigma_{ijk}}$ = random residual error

3.0 RESULTS AND DISCUSSION

Growth performance of rabbits reared in indoor and outdoor housing systems

Table 1 shows the growth performance of rabbits reared under indoor and outdoor housing systems. Rabbits reared under the outdoor system had significantly (P<0.05) higher feed intake (4521.6g) and significantly (P<0.05) higher water intake (11798.5ml) than rabbits reared indoor (4184.9g) and (9511.7ml). All other growth performance parameters considered (final weight, weight gain and feed conversion ratio) were not significantly (P>0.05) influenced by different housing systems. Results presented in Table 2 showed that sex had no significant (P>0.05) influence on all growth parameters of rabbits considered. The effect of the interaction of sex and housing systems on the growth performance of rabbits is presented in Table 3, it showed that the interaction of sex and housing systems had no significant (p> 0.005) influence on the growth performance of rabbits.

Table 1: Effect of housing systems on growth performance of rabbits

Parameters	Indoor	Outdoor	P- value
Initial weight (g)	1131.60±160.90	1173.70±423.40	0.71
Final weight (g)	1917.80±203.92	2050.00±352.97	0.17
Total Feed intake (g)	4184.90±374.47[b]	4521.60±567.41[a]	0.04
Total Weight gain (g)	786.30±220.11	876.30±470.13	0.41
FCR	5.64±1.34	7.91±8.44	0.26

FCR: Feed conversion ratio

[a b]: Means in the same row with different superscripts differ significantly (P<0.05)

Table 2: Growth performance of different sex of rabbits

Parameters	Female	Male	P- value
Initial weight (g)	1118.40±301.94	1186.84±335.34	0.53
Final weight (g)	2024.74±278.57	1943.16±307.03	0.36

Feed intake (g)	4325.30±472.51	4381.20±545.07	0.81
Weight gain (g)	906.30±387.53	756.30±334.20	0.19
FCR	6.79±8.26	6.75±2.74	0.93

FCR: Feed conversion ratio

Table 3: Effect of interaction of sex and housing systems on growth performance of rabbits

Parameters	**Indoor**		**Outdoor**		
	Female	**Male**	**Female**	**Male**	**P- value**
Initial weight(g)	1165.00±74.72	1094.44±221.42	1066.67±439.45	1270.00±406.34	0.19
Final weight(g)	1971.00±161.62	1858.89±238.19	2084.44±370.94	2019.00±353.00	0.81
Feed intake(g)	4230.90±378.77	4133.72±385.39	4430.11±563.44	4603.90±588.05	0.39
Weight gain (g)	806.00±210.45	764.44± 241.15	1017.78±511.39	749.00±414.20	0.34
FCR	5.51± 1.26	5.79±1.50	8.23±12.13	7.63±3.36	0.83

FCR: Feed conversion ratio

Effects of different housing systems on physiological response of rabbit

Table 4 presents the physiological data of rabbits reared under two distinct housing systems. Result revealed that rectal temperature and body temperature were not significantly (P>0.05) impacted by housing systems. Table 5 indicates the effect of sex on the physiological response of rabbits. Result showed that all parameters studied were not substantially (P>0.05) impacted by sex. Table 6 indicated the relationship of sex and housing systems on the physiological response of rabbits. The relationship of the housing system and sex did not significantly (P>0.05) affect any physiological parameters.

Table 4: Effects of different housing systems on physiological data of rabbits

Parameters	**Indoor**	**Outdoor**	**P-value**
Rectal temperature morning (°C)	37.96±0.04	37.99±0.05	0.53
Rectal temperature evening (°C)	38.31±0.05	38.28±0.05	0.63
Body temperature morning (°C)	38.88±0.04	38.76±0.06	0.07
Body temperature evening (°C)	39.18±0.03	39.11±0.03	0.13

[a b]: Means in the same row with different superscripts differ significantly (P<0.05)

Table 5: Effect of sex on the physiological response of rabbits

Parameters	**Female**	**Male**	**P-value**
Rectal temperature morning (^{0}C)	37.94±0.05	38.02 ±0.05	0.27
Rectal temperature evening (^{0}C)	38.26±0.05	38.33±0.05	0.38
Body temperature morning (^{0}C)	38.76±0.05	38.89±0.04	0.05
Body temperature evening (^{0}C)	39.14±0.03	39.15±0.04	0.90

Table 6: Interactive effect of sex and housing system on the physiological response of rabbits

	Indoor		**Outdoor**		
Parameters	**Female**	**Male**	**Female**	**Male**	**P-value**
Rectal temperature morning (^{0}C)	37.94±0.06	37.98±0.06	37.95±0.07	38.05±0.07	0.65
Rectal temperature evening (^{0}C)	38.29±0.06	38.33±0.07	38.23±0.07	38.32±0.08	0.76
Body temperature morning (^{0}C)	38.85±0.05	38.92±0.06	38.67±0.08	38.85±0.07	0.38
Body temperature evening (^{0}C)	39.16±0.06	39.20±0.03	39.12±0.33	39.09±0.06	0.58

Haematological indices of sexed rabbits under different housing system

Table 7 shows the haematological indices of rabbits reared under indoor and outdoor housing systems. Results showed that housing systems had no significant (P>0.05) effect on the haematological

parameters of the rabbits. The effect of the sex of rabbits on the haematological indices of rabbits is shown in Table 8. Results revealed that sex had no significant (P>0.05) effect on the rabbits' haematological parameters considered at the initial and final stages of the experiment. The impact of the interaction of sex and housing systems (indoor and outdoor) on the haematological indices of rabbits is as shown in Table 9. Haematological parameters of rabbits considered were not significantly (P>0.05) influenced by the interaction of sex and housing system at both the initial and final stages.

Table 7: Effects of housing system on the haematological indices of rabbits

Parameters	Indoor	Outdoor	P-value
Packed cell volume (%)	37.00±3.71	39.40±4.43	0.12
Hemoglobin (g/dl)	12.37±1.24	14.62±5.54	0.19
White blood cell ($x10^9$/L)	8564.00±1878.08	18050.00±26006.46	0.26
Red blood cell ($x10^{12}$/L)	4.94±0.51	5.28±0.51	0.10
Means corpuscular volume (fl)	61.03±3.66	60.19±1.94	0.51
Mean cell haemoglobin concentration (g/dl)	25.56±0.92	25.75±0.92	0.64
Mean cell haemoglobin (pg)	40.89±1.32	40.97±5.52	0.96

Table 8: Effect of sex on the haematological indices of rabbits

Parameters	Female	Male	P-value
Packed cell volume (%)	37.70± 5.19	38.70± 3.020	0.50
Hemoglobin (g/dl)	14.22± 5.74	12.77± 1.00	0.39
White blood cell ($x10^9$/L)	17107± 26367.42	9507± 1589.00	0.36
Red blood cell ($x10^{12}$/L)	5.07± 0.60	5.15± 0.46	0.68
Means corpuscular volume (fl)	60.99± 2.4946	60.23 ±3.32	0.55
Mean cell haemoglobin concentration (g/dl)	25.47± 0.94	25.84± 0.87	0.37
Mean cell haemoglobin (pg)	41.44± 1.35	40.42± 5.46	0.58

Table 9: Effect of sex and housing system on the haematological indices of rabbits

	Indoor		Outdoor		
Parammeters	Female	Male	Female	Male	P-value
Packed cell volume (%)	34 00± 2.55	40.00± 1.41	41.40 ±4.44	37.40±3.78	0.00
Hemoglobin (g/dl)	11.40± 0.83	13.34± 0.63	17.04± 7.31	12.20± 1.02	0.06
White blood cell ($x10^9$/L)	7454 ±936.79	9674 ±1994.58	26760 ±36475.51	9340± 1277.88	0.24
Red blood cell ($x10^{12}$/L)	4.62 ±0.38	5.26± 0.43	5.52 ±0.41	5.04 ±0.52	0.11
Means corpuscular volume (fl)	62.46± 1.43	59.60± 4.80	59.52± 2.56	60.86± 0.88	0.12
Mean cell haemoglobin concentration (g/dl)	25.64± 0.87	25.48± 1.10	25.30± 1.1	26.20±0.5	0.21
Mean cell haemoglobin (pg)	40.40± 0.89	41.38 ±1.60	42.48± 0.80	39.46± 7.89	0.29

Serum biochemistry of sexed rabbit under different housing system

Table 10 shows the serum biochemical parameters of rabbits reared indoor and outdoor housing systems. Result showed that at the initial stage rearing rabbits on two different housing systems (indoor and outdoor) had significant (P<0.05) effect on creatinine parameters of rabbits, with rabbits reared outdoor had significant (P<0.05) higher creatinine level (0.99 $mgdl^{-1}$) than those reared indoor (0.62 $mgdl^{-1}$). Other serum parameters considered were not significantly (P>0.05) affected by different housing systems. Table 11 shows the effect of sex on the serum biochemical parameters of rabbits. All serum biochemical parameters considered were not significantly (P>0.05) influenced by the sex of rabbits. The interactive effect of sex and housing systems on serum biochemical parameters of rabbits presented in Table 12 of this experiment revealed that interaction of sex and housing systems had no

significant (P>0.05) effect on the serum biochemical indices of rabbits.

Table 10: Effect of housing system on serum biochemical parameters of rabbits

Parameters	Indoor	Outdoor	P-value
Total protein g/dl	6.77± 0.28	6.82± 0.46	0.80
Albumin g/dl	3.82±0.16	3.87±025.	0.62
Globulin g/dl	2.96±0.37	2.91±0.54	0.82
Aspartate amino transferase (U/L)	65.70±8.00	65.30±6.63	0.90
Alanine amino transferase (U/L	56.50±6.93	56.90±8.69	0.92
Glucose (mg/dl)	115.78±16.98	116.48± 29.00	0.95
UREA	16.16±7.33	16.06±5.33	0.97
Creatinine ($mgdl^{-1}$)	1.79± 0.66	1.87± 0.68	0.79

[a b]: Means in the same row with different superscripts differ significantly (P<0.05)

Table 11: Effect of sex on serum biochemical parameters of rabbits

Parameters	Female	Male	P-value
Total protein g/dl	6.87±0.47	6.72±0.23	0.38
Albumin g/dl	3.84±0.26	3.85±0.15	0.92
Globulin g/dl	3.01±0.55	2.86±0.33	0.49
Aspartate amino transferase	63.90±5.30	67.10±8.62	0.34
Alanine aminotransferase	56.10±4.91	57.30±9.93	0.75
Glucose	113.37±17.14	118.89±28.62	0.63
UREA	13.63±6.29	18.60±5.37	0.29
Creatinine	1.89±0.80	1.77±0.21	0.69

Table 12: Effect of sex and housing systems on serum biochemical parameters of rabbits

	Indoor		Outdoor		
Parameters	**Female**	**Male**	**Female**	**Male**	**P-value**
Total	6.74± 0.30	6.80± 0.27	7.00± 0.60	6.64 0.18	0.23
Albumin	3.80± 0.17	3.84± 0.17	3.88± 0.34	3.86± 0.15	0.77
Globulin	2.92± 0.36	2.98± 0.41	3.08± 0.73	2.74± 0.18	0.37
Aspartate amino transferase	62.00± 4.18	69.4± 9.61	65.8± 6.06	64.8 ±7.85	0.21
Alanine amino transferase	55.60±5.18	57.4±8.91	56.6 ±5.18	57.2± 11.95	0.87
Glucose	115.44± 10.18	116.12± 23.35	111.30± 23.38	121.66±35.76	0.66
Urea	14.10± 7.64	18.22± 7.19	13.16± 5.49	18.96 ±3.57	0.76
Creatinine	2.08± 0.71	1.50± 0.37	1.70± 0.83	2.04± 0.52	0.14

Effect of sex and housing systems on stress markers of rabbits

Table 13 shows the effect of housing systems (indoor and outdoor) on the cortisol levels of rabbits. Significantly (P<0.05) higher cortisol levels were observed in rabbits reared outdoors (6.655) compared (p> 0.05) to those reared indoors (5.218). Table 14 revealed the effect of sex on the level of rabbits. Results showed that female rabbits had significantly (P<0.05) higher cortisol levels (6.59 and 6.94) when compared with the cortisol levels of their male counterpart (4.44 and 4.93). The effect of the interaction of sex and the housing system on the stress level of rabbits is shown in Table 15. Results showed that the interaction of sex and housing systems had no significant (P>0.05) influence on the stress level of rabbits.

Table 13: Effect of housing systems on cortisol level of rabbits

Parameters	Indoor	Outdoor	P-value
Cortisol (mcg/dL)	5.218±0.56[b]	6.655±0.52[a]	0.02
Superoxidase dismutase	0.00± 0.00	0.00± 0.00	0.00
Glutathione peroxidase	24.9±6 8.01	25.60± 6.09	0.82

Table 14: **Effect of sex on cortisol level of rabbits**

Parameters	Female	Male	P-value
Cortisol (mcg/dL)	6.94±0.43[a]	4.93±0.45[b]	0.01
Superoxide dismutase	0.00± 0.00	0.00 ±0.00	0.25
Glutathione peroxidase	23.73 8.04	26.83 5.74	0.33

[a b]: Means in the same row with different superscripts differ significantly (P<0.05)

Table 15: Interaction of sex and housing system on the cortisol level of rabbit

	Indoor		Outdoor		
Parameters	**Female**	**Male**	**Female**	**Male**	**P-value**
Cortisol	6.20±0.50	4.24±0.59	7.68±0.34	5.63±0.44	0.92
Superoxide dismutase	0.00± 0.00	0.00 ±0.00	0.00± 0.00	0.00± 0.00	0.58
Glutathione peroxidase	20.26± 9.22	29.66± 2.72	27.20± 5.52	24.00± 6.84	0.35

Discussion

The result obtained on the growth performance of rabbits in this study revealed that feed intake and water intake were only significant when rabbits were reared under two different housing systems, with rabbits reared outdoors consuming more water and feed. Increased water intake in rabbits reared outdoors can result from the higher environmental temperature the rabbits were subjected to, thus rabbits need to consume more water to reduce heat stress caused by higher temperatures. Increased water intake can lead to an increase in the feed intake of rabbits (Tschudin et al., 2011). The result was in line with the study of Krohn et al., (1999) and Rizzi et al., (2008) who reported that rabbits consumed more water when reared outdoors than when kept indoors. The current study's findings also show that while housing systems boosted feed and water intake, they had no discernible effect on other growth performance metrics, such as weight gain, ultimate weight, and feed conversion ratio. This conclusion was consistent with a study by Rizzi et al. (2008) that found that while rabbits housed outside consumed more food, their body weight did not increase noticeably above those kept indoors. However, the D'Agata et al. (2009) study, which found that raising rabbits outside significantly improved their growth performance, conflicted with this conclusion. Results obtained from this study revealed no visible difference in all growth performance parameters (Feed intake, weight gain, final weight, water intake and feed conversion ratio) as a result of sex difference. This result contradicted the study of Salisu and Erakpotobor, (2014) who recorded higher feed intake and body weight in female rabbits than in male rabbits.

The result of the physiological data obtained in this study collaborated with the report of Lambertini et al., (2001) and Machado et al., (2019) who reported higher environmental temperatures in the outdoor housing system of rabbits than indoor housing system. It was noticed that while environmental temperature was affected by housing systems, rectal temperature and body temperature were influenced by housing systems. This result further explained the reason for the increase in water intake as an increase in water intake is a coping mechanism for rabbits subjected to higher environmental temperatures (Ramnaraine, 2017). Result in this study showed that body temperatures were similar in both sexes, and this in line with the study of Akinsola (2012) who reported no significant difference in the body temperature of both male and female rabbits. Jimoh and Ewuola (2018) reported the rectal temperature of male rabbits averaged 37.60°C in the morning and 38.4°C in the evening, while female rectal averaged 37.41°C in the morning and 37.92°C in the evening. Although the rectal temperature values in the above study and those in this study differ slightly. However, the current study is similar to that reported by Jimoh and Ewuola (2018), who also reported no significant difference in the rectal temperature of male and female rabbits. The difference in the rectal temperature values can be as a result of environmental differences as Jimoh and Ewuola (2018) study was carried out in Oyo state, while this study was carried out in Ogun state. The interaction of sex and housing had no visible effect on the physiological state of rabbits, this result supported the findings of Massaro *et al.*, (2006) who reported no significant difference in the physiological data (body temperature, rectal temperature and respiratory rate) of both male and female rabbits reared under different housing systems.

Haematological indices are an index and a reflection of the status of the blood available for an animal to meet its physiological, biochemical and metabolic necessities (Ewuola et al., 2004). Results on the haematological indices showed that all haematological indices considered were within the normal blood haematology range of rabbit reported by Ewuola et al. (2004) and Etim et al. (2014). This result contradicted the study of Aderemi (2004) who stated that the haematological parameters of animals can be affected by the environment. The haematological indices on sex results also contradicted the study of Chineke et al. (2006) who stated that sex can influence the haematological parameters of rabbits, with male rabbits having higher values than females Hb, PCV, and RBC. Also, Animashahun et al. (2006) reported that haematological values may be influenced by sex, age and nutrition among others.

The result of this present study on the serum biochemical indices showed that although there was a slight difference in the creatinine level of rabbits as a result of different housing systems at day 1 of the experiment, the serum biochemical indices were still within the normal range reported by El-Banna et al. (2005). The increased level of creatinine in rabbits reared outdoors can be as a result of a change in environmental temperature subjected to on the first day. The result was in contrast with the study of Mutwedu et al., (2021) who

reported no significant difference when rabbits were reared in different housing systems. Differences in the result of this present study and Mutwedu et al., (2021) can be as a result of the different region where the experiment was carried out (Temperate and Tropical region). Furthermore, the serum levels in both male and female rabbits were not significantly different. This report supported the findings of Ayo-Ajasa et al., (2015) who reported no significant difference in serum parameters of both male and female rabbits.

One hormone that shows a body's reaction to stress is cortisol. According to Perez-Fuentes *et al*. (2020), rabbits housed in outdoor housing types may have been subjected to higher levels of chronic stress, which could indicate that their welfare conditions were not optimal. In this study, cortisol concentration was greater in rabbits reared outdoors than those reared indoors and this can be associated with the higher environmental temperature in outdoor housing. This result was in line with the report of Pérez-Fuentes et al., (2020) who reported a significant increase in the cortisol level of rabbits as environmental temperature increased. This conclusion is in line with recent research that found that rabbits raised outdoors had faecal corticosterone concentrations three times higher than those raised indoors (Szendrő et al., 2012). Similar findings were made by Mugnai *et al*. (2011) and Rommers et al. (2006) about elevated corticosterone concentrations in communally raised rabbits. The result in this present study was in line with the report of Bayazit and Khan (2005) who stated that cortisol levels were significantly higher in female rabbits than in male rabbits. Increased level in cortisol in female rabbits is an indication that male rabbits can withstand stressors better than female rabbits.

4.0 CONCLUSION

From this study, it could be concluded that:

- Rearing rabbits in outdoor housing increased feed intake and water intake, without enhancing body growth,
- Growth performance was also not different between male and female rabbits.
- Body temperature and rectal temperature were not significantly affected by sex and housing systems.
- Haematological parameters of rabbits were not affected by either sex or housing system (indoor and outdoor).
- Creatinine level was higher in rabbits kept outdoor than those kept indoor but did not vary with sex.
- Cortisol level was higher in rabbits reared outdoor than those reared indoor, and female rabbits indicated higher cortisol level than male rabbits under outdoor system

Recommendation

The following recommendations were made from results of this study:

- To reduce feed intake while still maintaining optimal growth performance, rearing rabbits indoor is recommended.
- To reduce stressors in rabbits, rearing rabbit's indoor housing is recommended.
- Only male rabbits may be considered for production rearing where outdoor housing is paramount.

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