EFFECT OF DIETARY LEVELS OF VITAMIN C ON GROWTH, THERMOREGULATORY RESPONSES AND REPRODUCTIVE PERFORMANCE OF RABBIT BUCKS IN THE HOT- DRY AND COOL-WET SEASON IN ZARIA, NIGERIA.

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DECLARATION

I declare that the work in this thesis entitled "**Effect of Dietary Levels of Vitamin C on Growth, Thermoregulatory Response and Reproductive Performance of Rabbit Bucks in the Hot-Dry and Cool-Wet Season in Zaria, Nigeria**" was done by me in the Department of Animal Science under the supervision of Professor (Mrs) G.T. Iyeghe-Erakpotoborand Dr. P.P. Barje. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this thesis was previously presented for another degree or diploma at any University.

_____ _____

BISONG KINGSLEY OBI DATE

CERTIFICATION

This thesis entitled "**Effect of Dietary Levels of Vitamin C on Growth, Thermoregulatory Response and Reproductive Performance of Rabbit Bucks in the Hot-Dry and Cool-Wet Season in Zaria Nigeria.**" by Bisong Kingsley Obi meets the regulation governing the award of the degree of Master of Science of the Ahmadu Bello University, Zaria and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

I dedicate this thesis to Almighty God who is the fountain of life and to my dearest mother, Mrs. Julia B. Ajom Bisong.

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TABLE OF CONTENTS Pages

Title page- - - - - - - - - - i

Declaration- - - - - - - - - - - ii

Certification - - - - - - - - - - iii

Dedication - - - - - - - - - - iv

Acknowledgements - - - - - - - - - v

Abstract - - - - - - - - - - xvii

Table of Contents - - - - - - - - - vi

List of Tables - - - - - - - - - - xiii

List of Figures - - - - - - - - - - xv

Abbreviation - - - - - - - - - - xvi

CHAPTER ONE

1.0 INTRODCUTION - - - - - - - - - 1

1.1 Justification - - - - - - - - - - 2

1.2 Research Hypothesis- - - - - - - - - 3

1.3 Objectives of Study - - - - - - - - - 3

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1. Concept of Heat Stress - - - - - - - - - 4

2.1.1 Effect of Heat Stress on Physiological Parameters - - - - 5

2.1.2 Effect of Heat Stress on Growth Performance - - - - - 5

2.1.3 Effect of Heat Stress on Enzymes - - - - - - 6

2.1.4 Effect of Heat Stress on Hormones - - - - - - - 6

2.1.5 Effect of Heat Stress on Reproduction - - - - - - 7

2.2. Mechanism of Heat Stress Regulation in Rabbit Bucks - - - - 7

2.3 Functions of Vitamin C - - - - - - - - - 9

2.4. Performance Characteristics of Rabbit Bucks during Heat Stress - - - 12

2.4.1 Feed Intake- - - - - - - - - - - 12

2.4.2 Water Intake- - - - - - - - - - - 13

2.4.3 Weight Gain- - - - - - - - - - - 14

2.4.4 Scrotal Circumference - - - - - - - - - 14

2.4.5 Reaction Time- - - - - - - - - - 15

2.5 Indicators of Physiological Stress - - - - - - - 16

2.5.1 Skin Temperature- - - - - - - - - - 16

2.5.2 Ear Temperature- - - - - - - - - - 16

2.5.3 Scrotal Temperature - - - - - - - - - 17

2.5.4 Rectal Temperature - - - - - - - - - - 18

2.5.5 Respiratory Rate- - - - - - - - - - 19

2.5.6 Heart Rate - - - - - - - - - - - 20

2.6. Semen Characteristics - - - - - - - - - 20

2.6.1 Semen Volume- - - - - - - - - - 21

2.6.2 Sperm Motility - - - - - - - - - - 22

2.6.3 Semen pH - - - - - - - - - - - 23

2.6.4 Sperm Concentration - - - - - - - - - 24

2.6.5 Semen Colour - - - - - - - - - - 24

2.6.6 Live and Dead ratio - - - - - - - - - 25

2.7 Sperm Morphology and Abnormalities - - - - - - - 26

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Experimental Site - - - - - - - - - 28

3.2 Experimental Animals and Management - - - - - - 28

3.3 Data Collection - - - - - - - - - - 29

3.4 Statistical Analysis - - - - - - - - - 31

CHAPTER FOUR

4.0 RESULT

4.1 Average Monthly Ambient Temperature and Relative Humidity - - 34

4.2 Effect of Vitamin C Levels on Growth Performance of Rabbit Bucks - - 34

4.3 Effect of Breed on Growth Performance of Rabbit Bucks - - - - 37

4.4 Effect of Season on Growth Performance of Rabbit Bucks - - - 37

4.5 Effect of Month on Growth Performance of Rabbit Bucks - - - 40

4.6 Interaction between Vitamin C Levels and Breed on Growth Performance of Rabbit Bucks - - - - - - - - - - 42

4.7 Interaction between Vitamin C Levels and Season on Growth Performance of Rabbit Bucks - - - - - - - - - - 44

4.8 Interaction between Vitamin C Levels and Month on Growth Performance of Rabbit Bucks - - - - - - - - - - - 44

4.9 Interaction between Breed and Season on Growth Performance of Rabbit Bucks- 47

4.10 Interaction between Breed and Month on Growth Performance of Rabbit Bucks- 47

4.11 Effect of Vitamin C Levels on Thermoregulatory Parameters of Rabbit Bucks- 50

4.12 Effect of Breed on Thermoregulatory Parameters of Rabbit Bucks - - 50

4.13 Effect of Season on Thermoregulatory Parameters of Rabbit Bucks - - 50

4.14 Effect of Month on Thermoregulatory Parameters of Rabbit Bucks - - 54

4.15 Interaction between Vitamin C levels and Breed on Thermoregulatory Parameters of Rabbit Bucks - - - - - - - - - 54

4.16 Interaction between Vitamin C Levels and Season on Thermoregulatory Parameters of Rabbit Bucks - - - - - - - - - 57

4.17 Interaction between Vitamin C Levels and Month on Thermoregulatory Parameters of Rabbit Bucks - - - - - - - - - 57

4.18 Interaction between Breed and Season on Thermoregulatory Parameters of Rabbit Buck - - - - - - - - - - - 60

4.19 Interaction between Breed and Month on Thermoregulatory Parameters of Rabbit Bucks - - - - - - - - - - 60

4.20 Effect of Vitamin C Levels on Semen Characteristics of Rabbit Bucks- - 60

4.21 Effect of Breed on Semen Characteristics of Rabbit Bucks - - - 64

4.22 Effect of Season on Semen Characteristics of Rabbit Bucks - - - 64

4.23 Effect of Month on Semen Characteristics of Rabbit Bucks - - - 64

4.24 Interaction between Vitamin C Levels and Breed on Semen Characteristics of Rabbit Bucks - - - - - - - - - - - 65

4.25 Interaction between Vitamin C Levels and Season on Semen Characteristics of Rabbit Bucks - - - - - - - - - - - 65

4.26 Interaction between Vitamin C Levels and Month on Semen Characteristics of Rabbit Bucks - - - - - - - - - - - 65

4.27 Interaction between Breed and Season on Semen Characteristics of Rabbit Bucks- 65

4.28 Interaction between Breed and Month on Semen Characteristics of Rabbit Bucks- 73

4.29 Effect of Vitamin C Levels on Sperm Morphology of Rabbit Bucks - - 73

4.30 Effect of Breed on Sperm Morphology of Rabbit Bucks - - - 73

4.31 Effect of Season on Sperm Morphology of Rabbit Bucks - - - 77

4.32 Effect of Month on Sperm Morphology of Rabbit Bucks - - - 79

4.33 Interaction between Vitamin C Levels and Breed on Sperm Morphology of Rabbit Bucks - - - - - - - 79

4.34 Interaction between Vitamin C Levels and Season on Sperm Morphology of Rabbit Bucks - - - - - - - 80

4.35 Interaction between Vitamin C Levels and Month on Sperm Morphology of Rabbit Bucks - - - - - - - 80

4.36 Interaction between Breed and Season on Sperm Morphology of Rabbit Bucks - - - - - - - 87

4.37 Interaction between Breed and Month on Sperm Morphology of Rabbit Bucks - - - - - - - 87

CAPTER FIVE

5.0 DISCUSSION

5.1 Effect of Vitamin C Levels on Growth Performance - - - - 92

5.2 Effect of Breed on Growth Performance - - - - - 92

5.3 Effect of Season on Growth Performance - - - - - 93

5.4 Effect of Month on Growth Performance - - - - 94

5.5 Effect of Interaction between Vitamin C Levels and Breed on Growth Performance- 95

5.6 Effect of Interaction between Vitamin C Levels and Month on Growth Performance- 96

5.7 Effect of Interaction between Breed and Season on Growth Performance- - 96

5.8 Effect of Interaction between Breed and Month on Growth Performance- - 96

5.9 Effect of Vitamin C Levels on Thermoregulatory Parameters - - - 97

5.10 Effect of Season on Thermoregulatory Parameter - - - - 97

5.11 Effect of Month on Thermoregulatory Parameters - - - - 98

5.12. Effect of Interaction between Vitamin C Levels and Breed on Thermoregulatory Parameters - - - - - - - - - 99

5.13 Effect of Interaction between Vitamin C Levels and Season on Thermoregulatory Parameters - - - - - - - - - 100

5.14 Effect of Interaction between Vitamin C Levels and Month on Thermoregulatory Parameters - - - - - - - - - 100

5.15 Effect of Interaction between Breed and Season on Thermoregulatory Parameters- 100

5.16 Effect of Interaction between Breed and Month on Thermoregulatory Parameters- 101

5.17 Effect of Vitamin C Levels on Semen Characteristics - - - - 101

5.18 Effect of Breed on Semen Characteristics - - - - - 101

5.19 Effect of Season on Semen Characteristics - - - - - 101

5.20 Effect of Month on Semen Characteristics - - - - - 102

5.21 Effect of Interaction between Vitamin C Levels and Season on Semen Characteristics - - - - - - - - - 102

5.22 Effect of Vitamin C Levels on Sperm Morphology - - - - 102

5.23 Effect of Season on Sperm Morphology - - - - - 103

5.24 Effect of Month on Sperm Morphology - - - - - 103

5.25 Effect of Interaction between Vitamin C Levels and Breed on Sperm Morphology- 104

5.26 Effect of Interaction between Vitamin C Levels and Month on Sperm Morphology- 104

5.27 Effect of Interaction Breed and Season on Sperm Morphology - 104

5.28 Effect of Interaction between Breed and Month on Sperm Morphology - 104

CHAPTER SIX

6.0 SUMMARY, CONCLUSION AND RECOMMENDATION

6.1 Summary - - - - - - - - - - 105

6.2 Conclusion- - - - - - - - - - 109

6.3 Recommendation- - - - - - - - - - 110

6.4 References - - - - - - - - - - 111

LIST OF TABLES Pages

Table 3.1 Feed Compositions - - - - - - - 33

Table 4.1 Effect of Vitamin C Levels on Growth Performance of Rabbit Bucks - 36

Table 4.2 Effect of Breed on Growth Performance of Rabbit Bucks- - - 38

Table 4.3 Effect of Season on Growth Performance of Rabbit Bucks - - 39

Table 4.4 Effect of month on performance of rabbit bucks - - - - 41

Table 4.5 Effects of Interaction between Vitamin C Level and Breed on Growth Performance of Rabbit Bucks - - - - - - - - 43

Table 4.6 Effect of Interaction between Vitamin C Levels and Season on Growth Performance of Rabbit Bucks - - - - - - - - 45

Table 4.7 Effect of Interaction between Breed and Season on Growth Performance of Rabbit Bucks - - - - - - - - - 48

Table 4.8 Effect of Vitamin C Levels on Thermoregulatory Parameters of Rabbit Bucks- 51

Table 4.9 Effect of Breed on Thermoregulatory Parameters of Rabbit Bucks - 52

Table 4.10 Effect of Season on Thermoregulatory Parameters of Rabbit Bucks - 53

Table 4.11 Effect of Month on Thermoregulatory Parameters of Rabbit Bucks - 55

Table 4.12 Effect of Interaction Vitamin C levels and Breed on Thermoregulatory Parameters of Rabbit Bucks - - - - - - - - 56

Table 4.13 Effect of Interaction Vitamin C levels and Season on Thermoregulatory Parameters of Rabbit Bucks - - - - - - - - 58

Table 4.14 Effect of Interaction between Breed and Season on Thermoregulatory Parameters of Rabbit Bucks - - - - - - - - 61

Table 4.15 Effect of Vitamin C Levels on Semen Characteristics of Rabbit Bucks- 63

Table 4.16 Effect of Breed on Semen Characteristics of Rabbit Bucks - - 66

Table 4.17 Effect of Season on Semen Characteristics of Rabbit Bucks - - 67

Table 4.18 Effect of Month on Semen Characteristics of Rabbit Bucks - - 68

Table 4.19 Effects of Interaction between Vitamin C Levels and Breed on Semen Characteristics of Rabbit Bucks - - - - - - - - 69

Table 4. 20 Effect of Interaction between Vitamin C levels and Season on Semen Characteristics of Rabbit Bucks - - - - - - - - 70

Table 4. 21 Effect of Interaction between Season and Breed on Semen Characteristics of Rabbit Bucks- - - - - - - - 72

Table 4.22 Effect of Vitamin C Levels on Sperm Morphology of Rabbit Bucks - 75

Table 4.23 Effect of Breed on Sperm Morphology of Rabbit Bucks - 76

Table 4.24 Effect of Season on Sperm Morphology of Rabbit Bucks - - 78

Table 4.25 Effect of Month on Sperm Morphology of Rabbit Bucks - - 81

Table 4.26 Effect of Interaction between Vitamin C Levels and Breed on Sperm Morphology of Rabbit Bucks - - - - - - - - 82

Table 4.27 Effect of Interaction between Vitamin C Levels and Season on Sperm Morphology of Rabbit Bucks - - - - - - - - 83

Table 4.28 Effect of Interaction between Breed and Season on Sperm Morphology of Rabbit Bucks - - - - - - - - - 88

LIST OF FIGURES Pages

1. Average Ambient Temperature and Relative Humidity during the Study Period- 35

2. Effect of Interaction between Vitamin C Levels and Month on Growth Performance of Rabbit Bucks - - - - - - - - - 46

3 Effect of Interaction between Breed and Month on Growth Performance of Rabbit Bucks - - - - - - - - - - 49

4 Effect of Interaction between Vitamin C Levels and Month on Thermoregulatory Parameters of Rabbit Bucks - - - - - - - 59

5. Effect of Interaction between Breed and Month on Thermoregulatory Parameters of Rabbit Bucks- - - - - - - - - - - 62

6. Effect of Interaction between Vitamin C Levels and Month on Semen Characteristics of Rabbit Bucks- - - - - - - - - - 71

7. Effect of interaction between Breed and Month on Semen Characteristics of Rabbit Bucks- - - - - - - - - - - 74

8. Effect of Interaction between Vitamin C Levels and Month on Sperm Morphology of Rabbit Bucks - - - - - - - - - - 84

9. Effect of Interaction between Breed and Month on Sperm Morphology of Rabbit Bucks - - - - - - - - - - 89

List of Abbreviations

Abbreviations	Meaning
Kg	Kilogram
ml	Minilitter
cm	Centimeter
g	Gram
mg	Milligram
S	Second
NZW	New Zealand White
CAL	California
NAPRI	National Animal Production Research Institute

ABSTRACT

The experiment was carried out to investigate the effect of dietary vitamin C levels on growth performance, thermoregulatory response, and semen characteristics of rabbit bucks in the hot-dry and cool-wet season of Zaria Nigeria. A total of 55 10 month old rabbit bucks consisting of 40 (NZW) pure and 15 (NZW×CAL) crossbred Hyla rabbits were allotted in a 2× 2×4 factorial arrangement in a Completely Randomized Design. The factors considered were vitamin C levels (100 control, 200, 300 and 400 mg/kg) season (hot dry: March-June and cool wet: July-August), breed (pure and crossbred). Results obtained showed that vitamin C levels had significant ($p<0.01$) effect on growth performance. Breed had significant ($p<0.05$) effects on growth performance. Season had significant ($p<0.01$) effect on growth performance. Month had significant ($p<0.01$) effect on growth performance. There was interactions between vitamin C levels and breed on growth performance ($p<0.01$). There was interaction between vitamin C levels and month on growth performance ($p<0.05$). There was interaction between breed and season on growth performance ($p<0.01$). There was interaction between breed and month on growth performance ($p\leq0.01$). Vitamin C levels had significant ($p<0.05$) effect on thermoregulatory response. Season had significant ($p<0.01$) effect on thermoregulatory response. Month had significant ($p<0.01$) effect on thermoregulatory response. There was interaction between vitamin C levels and breed on thermoregulatory response ($p<0.01$). There was interaction between vitamin C levels and season on thermoregulatory response ($p<0.05$). There was interaction between vitamin C levels and month on thermoregulatory response ($p<0.05$). There was interaction between breed and season on thermoregulatory response ($p<0.01$). There was interaction between breed and month on thermoregulatory response ($p<0.05$). Vitamin C levels had significant ($p<0.05$) effect on semen characteristics. Breed had significant ($p<0.05$)

effects on semen characteristics. Season had significant ($p<0.05$) effect on semen characteristics. Month had significant ($p<0.05$) effect on semen characteristic. There was interactions between vitamin C levels and season on semen characteristics ($p<0.05$). Vitamin C levels had significant ($p<0.05$) effect on sperm morphological abnormalities. Season had significant ($p<0.05$) effect on sperm morphological abnormalities. Month had significant ($p<0.01$) effect on sperm morphological abnormalities. There was interaction between vitamin C levels and breed on sperm morphological abnormalities ($p<0.05$). There was interaction between vitamin C levels and month on sperm morphological abnormalities ($p<0.01$). There was interaction between breed and season on sperm morphological abnormalities ($p<0.05$). There was interaction between breed and month on sperm morphological abnormalities ($p<0.05$). It is concluded from this study that crossbred bucks performed better on 200 mg vitamin C, while purebred bucks performed better on 400 mg vitamin C.

CHAPTER ONE

1.0 INTRODUCTION

Reproductive inefficiency is one of the most limiting constraints to efficient rabbit production. The efficiency of spermatozoa production, libido, and semen quality changes throughout the reproductive life of an animal due to nutrition, environment, health status, drugs, and chemicals (Ifeanyi, 2009). In tropical countries, high temperature hinders the success of rabbit farming (Cervera *et al.*, 1997) as it leads to a significant reduction in daily weight gain, feed intake and feed efficiency (Chiericato *et al.*, 1993). A very important limitation to rabbit production in a hot climatic area is heat stress. Susceptibility to heat stress produces a series of changes in biological functions which in turn lead to impairment of production and reproductive function (Marai *et al.*, 1999). Such detrimental effects are evident during the hot season of the year, which are reflected in limiting the breeding season of rabbits, normally from May to September in the Northern hemisphere (Marai *et al*., 1996).

The effect of heat stress is aggravated when heat is accompanied by high humidity (Habeeb *et al.*, 1993; Marai *et al.*, 1996; 2001). The changes that occur in rabbits biological functions are depressed feed intake, feed efficiency, utilization, and disturbance in metabolism of water, protein, energy, mineral balance, enzymatic reaction, hormonal secretions and blood metabolites (Marai *et al.*, 2002).

In rabbits, stress associated with exposure to high ambient temperature decreases growth performance, possibly because it destroys cellular biological molecules (Liu *et al.*, 2011). During stress episode, reactive oxygen species (ROS) generation exceeds the body antioxidant production capacity, and oxidative stress develops (Roth, 2000). These active metabolites could

result in drastic damage to cell structures, protein, lipid, and DNA, and further induce physiological and pathological changes, resulting in poor performance, reduced welfare of the live animal and worsen its meat quality (Abdel-Kalek, 2010). Endogenous antioxidant enzymes are the major cell defense against oxidative stress (El-Medany *et al.,* 2012). Glutathione peroxidase (GSH-PX) and catalase (CAT) are considered the major peroxide removing enzymes located in the cytosol (El-Medany *et al.,* 2012).

Superoxide dismutase (SOD) plays an important role in protecting against damage by the superoxide anion radical (Chan and Decker, 1994). Dietary supplementation has been proven to be a simple and convenient strategy to introduce natural antioxidant that may effectively inhibit the reactive oxygen species reaction (ROS) (Botsoglou *et al.*, 2004). Vitamin C is widely used to alleviate heat stress in rabbits, more over this vitamin promotes growth, reproduction, and counteracts infections by pathogenic bacteria and viruses (Wang *et al.*, 2004). It also serves as nutritional supplement, as well as reduce metal ions that generate free radicals (Valko *et al.*, 2005). It is also a co-factor in at least eight enzymatic reactions including several collagen synthesis reactions that, when dysfunctional, causes the most severe symptom of scurvy in animals, these reactions are especially important tin wound healing and preventing bleeding from capillaries (Kotze *et al*., 1974). Vitamin C induces suppression of serum aspartate aminotransferase (AST) and glutamate pyruvate transaminase (ALT). Administration of vitamin C revealed protective activity against the toxic metabolites of diabetes (Hussein *et al.*, 2012).

1.1 **Justification**

Fertility of rabbit bucks is the basis of reproductive success in rabbit production (Al-Sobayil and Khalil, 2002). The use of antioxidant agent to improve fertility during environmental stress

becomes necessary (Marai *et al.*, 2002). Vitamin C have been reported to increase body resistance to environmental stress by reducing the synthesis and secretion of corticosteroids, thus alleviating the negative effects of stress (Roth and Kaeberle, 1985). The present study is designed to examine the effects of dietary vitamin C levels on growth, thermoregulatory response and reproductive performance of rabbits bucks in hot-dry and cool-wet season .

1.2 **Research Hypothesis:**

(1). Null Hypothesis (H_O): Vitamin C levels have no effect on growth performance, thermoregulatory response and semen characteristics of rabbit bucks

(1). Alternative Hypothesis (H_A): Vitamin C levels have effect on growth performance, Thermoregulatory response and semen characteristics of rabbit bucks

(2). Null Hypothesis (Ho): Season and breed have no effect on growth performance, thermoregulatory responses and semen characteristics of rabbit bucks given graded levels of vitamin C.

(2). Alternative Hypothesis (H_A): Season and breed have effect on growth performance, thermoregulatory responses and semen characteristics of rabbit bucks given graded levels of vitamin C.

1.3 **Objectives**

The specific objectives of the study were:

1. To evaluate effect of dietary vitamin C levels on growth performance, thermoregulatory responses and semen characteristics of rabbit bucks.
2. To evaluate effect of season and breed on growth, thermoregulatory responses and semen characteristics of rabbit bucks given graded levels of vitamin C.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1. Concept of Heat Stress

Fraser *et al.* (1975) in Rafel *et al.* (2012) defined stress as a state that occurs when an animal is required to make abnormal or extreme adjustments in either its physiology or behaviour in order to cope with adverse aspects of its environment and management. A combination of environmental factors (such as thermal radiation, sunlight, air temperature and humidity) and physiological activities such as metabolic rate can induce heat stress (Ajakaiye *et al.*, 2011).

Heat stress could be defined as a negative energy balance between the net amount of energy flowing from the animal to it surrounding environment and the amount of heat energy produced by the animal (Ajakaiye *et al.,* 2011). Dobson and Smith (2000) in Ganaie *et al*. (2013) defined stress as the inability of an animal to cope with its environment. Rosales (1994) in Ganaie *et al.* (2013) defined stress as the cumulative detrimental effects of various factors on health, performance and reproduction of an animal. Although rabbits are homoeothermic animal, they have few functional sweat glands which limits their ability to eliminate excess body heat when the environmental temperature is high (Rafel *et al*., 2012).

In spite of the imbalance in the amount of energy that flows from the animal to its environment, rabbits as homoeothermic animals can regulate the input and output of heat from their body through physical, morphological, biochemical, and behavioral processes to maintain a relative constant body temperature (Marai and Habeeb, 1994 in Ondruska *et al.*, 2011).

2.1.1 Effect of Heat Stress on Physiological Parameters

Physiological parameters such as respiratory rate, rectal temperature, scrotal temperature, skin temperature, and heart rate are strong verifiable indicators used to identify the response of rabbits to heat stress and consequently the level of discomfort or comfort to the animal (Bianca,1965). These parameters are used to measure comfortability and adaptability of the animal to adverse environmental conditions (Ganaie *et al.,* 2013).

The comfort zone for rabbits is 15^{o}C to 20^{o}C, this implies that rabbits can withstand cold than hot season (Balabel-Mousa, 2004). The metabolic activities of rabbits increase by about 20% when exposed to high temperature (Balabel-Mousa, 2004). The increase in physiological responses of rectal and scrotal temperature, heart rate and respiratory rate reflects the degree of stress imposed on the animal by climatic parameters Leagates *et al.* (1991) and could be used to access the adversity of thermal environment which affects growth, reproduction, and production of animals (West,1999). This also has significant correlation with circulatory corticoid concentration in the stressed animal (Kumar, 2005).

2.1.2 Effect of Heat Stress on Growth Performance

Rabbits exposed to heat stress or high air temperature shows decrease in feed intake and increase in water intake (Habeeb *et al.*,1993), this leads to a corresponding decrease in weight gain, and low productivity (Hassanein, 1980), also Okab *et al.* (2008) reported poor growth performance of rabbits during heat stress. Rabbit bucks exposed to unfavorable climatic condition tend to have decreased scrotal circumference which leads to significant reproduction impairment (Marai *et al.,* 1991).

Performance responses to heat stress have also been reported in other breeds like poultry as it inflicts economic losses as a result of stunted growth (Sahin and Kucuk 2001), high mortality,

depressed immunity and decreased production (Njoku and Nwazota 1989; Ayo *et al.,* 2010). In cattle, Tarr (2007) reported a decrease in dietary energy intake and loss of appetite as a response to heat stress, and a corresponding increase in water intake. Verstegen *et al.* (1987) reported a depression in feed intake in growing pigs as a response to heat stress.

2.1.3 Effect of Heat Stress on Enzymes

The plasma levels and activities of different enzymes are affected during heat stress (Bogin *et al.,* 1996). The activities of enzymes such as creatine kinase (CK), lactate dehydrogenase (LDH), glutamic-pyruvic transaminase (GPT), glutamicoxaloacetic transaminase (GOT) and aspartate aminotransferase (AST) responsible for the transfer of α-amino groups from specific amino acids to α-ketoglutaric acid to yield glutamic acid and oxalacetic acid or pyruvic acid, have their activities reduced during heat stress (Melesse *et al.,* 2011). Heat stress suppressed, the production capacity of endogenous antioxidant enzymes such as glutathione peroxidase (GSH-PX), catalase (CAT), and superoxide dismutase (SOD) which serve as major cell defence, (El-Medany *et al.,* 2012).

2.1.4 Effect of Heat Stress on Hormones

Heat stress is associated with increase in cortisol and decrease in thyroid secretion, which reduces protein and carbohydrate metabolism (Souza *et al.,* 2002). Hormonal responses to stress have been considered as a mechanism to maintain homeostasis after unpleasant physical or psychological experience (Kvetnansky *et al.,* 2009).

Thermal or climatic factors provoke endocrine reaction including stimulation of the hypothalamic pituitary adrenal (HPA) axis and the release of arginine vasopressin (AVP) which plays a vital role in osmoregulation, body water conservation and blood pressure regulation (Aguilera, 1994). Heat stress has negative influence on serum luteinizing hormone and

testosterone Godfrey *et al.* (1990) and reduces the production of gonadotropin hormone (GnRH), from the hypothalamus, which signals the release of luteinizing and follicle stimulating hormones from the anterior pituitary which trigger for testosterone release from the leydig cells (Azawi *et al.,* 2012).

2.1.5 Effect of Heat Stress on Reproduction

High ambient temperature has negative effect on reproductive traits of rabbit bucks Marai *et al.* (2002) which results in decreased semen production and fertility by increasing semen pH values and morphological alterations, and also inducing a change in sperm motility and libido (Nizza *et al.,* 2003 ; Safaa *et al.,* 2008). Heat stress has negative influence on sperm motility, normal live sperm, concentration per ejaculate and total abnormal sperm, although it does not influence semen volume negatively (Boulbina *et al.,* 2012). Contradictorily, (Finzi *et al.,* 2000) reported that semen volume and pH are negatively influence by heat stress.

The negative influence of high ambient temperature on reproductive traits could be attributed to the degeneration of the germinal epithelium and the partial atrophy of the seminiferous tubules (Marai *et al.,* 1991). Also, increase in abnormal sperm rate during heat stress could be linked to defect in spermatogenesis, particularly in the last stage of differentiation of spermatids (Marai *et al.,* 1991). Reproductive traits may become permanently impaired, and may recover through adaptive processes (Welch 1993, in Finzi *et al.,* 2000).

2.2. Mechanisms of Heat Stress Regulation in Rabbit Bucks

Behavioural change is the first mechanism to account for the heat lost or gained. If behavioral change does not minimize heat stress, non-evaporative mechanism such as conduction, radiation, and convection of exchange of heat between an animal and its environment are used. Resistance to conductive (i.e. heat exchange from particle to particle) heat transfer is proportional to the

temperature gradient between the core and outer extremities or the outer extremities and environment (McDowell, 1972). As an animal increases in weight its ability to dissipate core heat outward decreases linearly and it becomes more susceptible to heat stress while decreasing its susceptibility to cold stress (McDowell, 1972).

During cold stress conditions, an animal is trying to retain its core body heat, while the environment is acquiring it due to the differing temperature gradients. The animal accounts for this loss of heat by increasing its maintenance energy requirements in order to produce extra heat at a rate of 1% for each 1˚C reduction in effective temperature below its lower threshold temperature (Nienaber and Hahn, 2007). In heat stress conditions, convection (i.e. heat exchange through liquid or gas) is accomplished by the redirection of blood flow to the extremities or lungs and its effectiveness is dependent on multiple factors including physical properties of the hair coat and size of the animal. When an animal is exposed to an adverse environment it reacts initially, by activation or acceleration of non-evaporative processes to remain at thermal equilibrium, defined as short-term adaptive changes (McDowell, 1972; Nienaber and Hahn, 2007).If non-evaporative physical processes fail to keep an animal at thermal equilibrium, evaporative processes take over (McDowell, 1972; Hahn and Iversen, 1999).

Evaporative heat transfer is not dependent on the temperature gradient, but becomes important when the environment is warmer than the animal body temperature and offend results in the inward flow of heat from the environment to the animal (Davis *et al.,* 2003). Animal factors that affect the efficiency of evaporative heat loss from the skin surface are sweat gland density, function and morphology, hair coat density, length, and color and regulation of epidermal

vascular supply (Davis *et al.*, 2003). A rise in respiratory heat loss through panting is one of the first physical signs of an animal experiencing heat stress (Nienaber and Hahn, 2007).

2.3. Functions of Vitamin C (Ascorbic acid and Ascorbate)

Vitamin C **(**ascorbic acid or ascorbate) is an organic chemical made up of six-carbon lactone and a water soluble micronutrient required for multiple biological functions (Halliwell and Evans 2001). Vitamin C is synthesized from glucose through a series of chain reactions catalyzed by enzymes in animals except when they are young or under stress condition (Halliwell and Evans 2001). It is a natural antioxidant that prevents increase in production of free radicals induced by oxidative damage to lipids and lipoproteins in various cellular compartments and tissues and is involved in many physiological functions (Sies *et al*., 1992).

Vitamin C plays a vital role in neurotransmitters, hormone synthesis, enzymatic reactions, as a neuromodulator and protect cell components from oxidative damage (Packer *et al.,* 1997). Ascorbic acid is involved in the metabolism of several amino acids, leading to the formation of hydroxyproline, hydroxylysine, norepinephrine, serotonin, homogenistic acid, and carnitine (Barnes and Kodicek, 1972). It also serves as modulator for cell growth, inhibits growth of tumour cells, and cell differentiation; it is involved in decarboxylation reaction and tyrosine metabolism (Barnes and Kodicek, 1972).

Vitamin C has enzymatic and non-enzymatic functions. Enzymatically, it functions through the hydrolysis of amino acids such as lysine, and proline to mention but a few. As non-enzymes it acts through the increase of gastric iron absorption (McDowell, 2000). Vitamin C is a vital antioxidant which reacts with and inactivates free radicals in water soluble compartment of the body in areas such as cytosol, plasma, and extracellular fluid and oxidized vitamin E through its

regeneration (McDowell, 2000). Vitamin C also plays others roles such as: prevention and reduction of severity of the common cold, prevention of cancer and prolonged life of cancer patients, lowering of serum cholesterol and severity of atherosclerosis, increased wound repair and normal healing processes increased immune response for prevention and treatment of infections, control of schizophrenia, inactivation of disease viruses, and prevention of megaloblastic anemia of formula-fed infants (McDowell, 2000).

Currently, vitamin C is the most widely used vitamin throughout the world because it is an effective antioxidant, has an important metabolic role as reducing agent and functions as an electron carrier (Naidu, 2003). Adenkola *et al.* (2010) reported that vitamin C is actively transported into tissues and its utilization increases during periods of stress and that the animals ability to produce vitamin C under stress may become inefficient leading to a reduction in plasma concentration. Increasing vitamin C concentrations through dietary supplement will thereby prevent tissue depletion (Naidu, 2003).

Neurons use ascorbic acid for many different chemical and enzymatic reactions, including the synthesis of neurotransmitters and hormones (Packer *et al.,* 1997; Arrigoni and De-Tulio, 2000). Studies on the interactions of extracellular ascorbic acid with various plasma membrane proteins, suggest that ascorbic acid may function as a neuromodulator (Packer *et al.,* 1997). It is a major chain-breaking antioxidant present both in seminal plasma and in the membrane (Wang *et al.,* 2002). It reacts directly with free radicals such as the peroxyl radical (ROO,) yielding lipid hydro- peroxides which can be removed by phospholipase GSH-Px systems and interrupt the lipid peroxidation process, that is why it is called a chain breaking antioxidant (Wang *et al.,* 2002). This antioxidant also prevents reduction in sperm motility finally. It scavenges all three important types of reactive oxygen species, namely superoxide, hydrogen peroxide, and hydroxyl

radicals (Agarwal *et al.,* 2004). Dabrowski and Ciereszko (1996) reported that the concentration of vitamin C in seminal plasma directly reflects dietary intake, and that lower level of vitamin C may lead to infertility and increase damage to sperm genetic material. The ravaging effects of oxidative free radicals are quenched by antioxidants (Akinwande and Adebule, 2003). The magnitude of stress depends on the ability of the tissue to detoxify reactive oxygen species; that is, antioxidant defenses.

Antioxidant supplementation may provide beneficial effects against stress-induced tissue damage (Sen, 2001; Yavuz *et al.,* 2004; Walingo, 2005; Hesta *et al.,* 2009). Vitamin C has been known to protect against lipid peroxidation of cytomembranes (Harapanhalli *et al.,* 1996; Tauler *et al.,* 2003; Lee *et al.,* 2006). It is therefore, conceivable that vitamin C administration to animals subjected to heat stress may ameliorate the adverse effects of thermal stress.

Alhassan *et al.*(2010) stated that vitamin C may be important in protecting and preserving erythrocyte membrane integrity, thereby prolonging the lifespan of erythrocytes thus, improving packed cell volume, haemoglobin, and erythrocyte count, and regulating white cell population, while reducing haemolysis in animals subjected to heat stress (Adenkola *et al.,*2010). Kutlu and Forbes (1993) reported that administration of 250 mg/kg body weight of vitamin C orally ameliorated the heat induced deterioration in performance and metabolism of broiler chicks. Vitamin C also exerts protective role against acute ultraviolet B-rays (Sunburn cell formation) (Kurata *et al.,* 1993), and could reduce aflatoxin induced liver cancer (Yu *et al.,* 1994). Vitamin C exerts hypothermic effect in livestock transported by road during dry hot season (Ayo *et al.,* 2005), in goats (Ayo *et al*., 2006), and pullets (Minka and Ayo, 2008). Ciereszko and Dabrowski (2000) reported that vitamin C plays a critical role in gamete quality of fish like other

vertebrates. Feeding of rainbow trout with vitamin C deficient diet for a long time results in decreased sperm concentration, poor motility, fertilizing ability and sperm lipid peroxidation increased (Dabrowski and Ciereszko, 1995; Liu *et al.*, 1997).

2.4. Performance Characteristics of Rabbit Bucks during Heat Stress

2.4.1 Feed Intake

Voluntary feed intake is affected by season in all breeds of livestock, especially during the hot dry season which is associated with heat stress (Habeeb *et al.*, 1993). Marai *et al.* (2001) reported a significant reduction in feed intake of rabbit bucks in hot dry season and an increase in cool wet season. The decrease in feed intake of rabbits and other species of livestock could be attributed to the stimulation of the peripheral thermal receptors to transmit suppressive nerve impulses to the appetite centre in the hypothalamus (Marai and Habeeb, 1998).

Matheron and Martial (1981) reported a decrease in feed consumption rate by rabbits when ambient temperature increased to about 30^0C, and increase in feed consumption rate when the temperature was below 30^oC**.** McLaren *et al.* (1987) reported that there was no significant variation in feed intake between purebred and crossbred animals. Similarly, Ilorie *et al.* (2010) reported no significant difference in feed intake between crossbred and purebred animals. Similarly El-Medany *et al.* (2012) reported that breed of rabbit had no influence on feed intake. While Abdel-Azeem *et al.* (2007) reported that feed intake of crossbred rabbits was significantly higher than that of purebred rabbits. Significant variations were not observed in feed intake of rabbits fed diets with vitamin C and without vitamin C (Adenkola *et al.* 2010).

However Gross (1988) reported an appreciable improvement of vitamin C on feed intake of stressed rabbits which resulted in good feed efficiency. Feed intake increased in rabbits with

increase in vitamin C level of inclusion in diet (Afify and Makled, 1995). Tuleun *et al.* (2011) reported significant increase in feed intake of quail fed diet supplemented with vitamin C.

2.4.2 Water Intake

Animals tend to consume more water during heat stress in other to replace or recover the water lost (King *et al.*, 1983). High water consumption by rabbits in hot dry season helps to increase heat loss through respiration, evaporation, and urination (Chiericato *et al.*, 1992; Marai and Habeeb, 1994). Highest rate of water intake was recorded in purebred than crossbred rabbits bucks Ilorie *et al.*(2010),implying that, the increase in water consumption was to compensate for water loss and to increase the heat dissipation capacity (Belay *et al*., 1992).

However, water retention capacity is reduced due to the increase in electrolyte excretion in urine and feces (Belay and Teeter, 1996). At this stage, if the amount of water lost is not completely compensated, dehydration and increased body temperature may occur which could reduce the performance ability of the animal (Belay *et al*., 1992). In other to avoid this problem, rabbits tend to consume more water (Zhou *et al*., 1999; Tanveer *et al*., 2005), resulting in plasma expansion, and reduced plasma osmolality and whole blood viscosity (Zhou *et al*., 1999).

High rate of water intake of rabbits fed vitamin C supplemented diets over non-vitamin C supplemented diet have been reported by (Adenkola *et al.*, 2010). Gross (1988) had earlier reported that vitamin C enhances rate of water intake by rabbits and other livestock. Tuleun *et al.* (2011) however did not observe significant variations in daily water intake by quails fed vitamin C supplemented diet and non-vitamin C supplemented diet.

2.4.3 Weight Gain

Daily body weight gain of rabbits are reduced in the hot dry season due to heat stress, which has be attributed to the negative effect on appetite centre which causes decrease in feed consumption rate Marai *et al.* (2002), while during cool wet season, daily body weight gain increases, may be linked to a positive feedback mechanism to the appetite centre for high feed consumption, as well as to reduce cold stress (Tarr, 2007).The variations in weight gain could be attributed to factors such as temperature, nutrition, disease, hormone and general management.

Heat stress occurs in the hot dry season which leads to significant reduction in daily weight gain in rabbit (Chiericato *et al.,* 1993). Abdel-Azeem *et al.* (2007) reported a significant variation in weight gain among breed of rabbits with crossbreds having higher weight gain, and growth rate than purebred. McLaren *et al.* (1987) also reported that purebred animals have higher weight gain, and were heavier than crossbred animals.

However, El-Medany *et al*. (2012) reported that breed had no effect on weight gain of rabbits. Gross (1988) reported that vitamin C supplementation improved weight gain. Significant increase in growth performance of rabbits fed vitamin C supplements was also reported by Afify and Makled (1995). The growth promoting factor of vitamin C may be associated with the alleviation of retardation in thyroid function (Coates, 1984).

2.4.4 Changes in Scrotal Circumference

Scrotal circumference is one of the traits used in breeding soundness evaluation of an animal for efficient reproduction (Godfrey *et al*., 1990). Hot dry season which causes heat stress, decrease scrotal circumference, while cool wet or rainy season increases scrotal circumference (Zeidan and Abbas, 2004 in Maiada *et al.,* 2013). High environmental temperature which occurs during

the hot dry season causes pendulous arrangement of the scrotum and decreases the wrinkling nature of the scrotal epithelium Zeiddan *et al.*(2001) and damages heat sensitive germ cells, pachytene, spermatocytes and early spermatids (Setchell *et al.,* 2001).

Scrotal circumference has also been reported by Ugwu *et al.* (2009) to be different with age, weight of animals and month. The scrotal circumference was reported to decrease in the month of February and increase from March to May, but higher values were recorded from the months of June to August. On the same trend, Ugwu *et al.* (2009) reported that scrotal circumference and testis width are highly significantly seasonally influenced with higher values in rainy season than dry season. Significant difference was not observed in scrotal circumference of animals administered graded levels of vitamin C (Fazeli *et al.,* 2010).

2.4.5 Reaction Time

Reaction time which is known to be the time it took an animal to sniff, groom and mount the doe to ejaculation is reported to decrease as the ambient temperature increases (Boulbina *et al.,* 2012). Increase ambient temperature also inflicts changes in libido and sperm motility of rabbit bucks (Nizza *et al.,* 2003). High libido has been reported to be very vital and beneficial in terms of pregnancy rate, time of conception, parturition season and weaning (Scheepers *et al.,* 2010).

An alteration in libido by ambient temperature changes these beneficial effects and reduces reproduction, production and the economy of the farmer (Scheepers *et al.,* 2010). Brillard (2003) postulated that during heat stress episodes, mating activity, and sexual arousal behavior (libido) are strongly impaired, presumably through dehydration and alteration in secretion of sex hormones, unlike in cool wet seasons. Galina *et al.* (2007) demonstrated that libido is neither related to semen quality nor to scrotal circumference, so it is possible to obtain an excellent

semen sample from animals with low libido. Crossbred animals have been reported to be of high vigour and possess greater libido and higher fertility rate than purebred, and therefore the use of crossbreds in commercial farming could increase breeding efficiency (McLaren *et al.,* 1987). The report of Seleem *et al.* (2008) indicates that libido values of purebred were significantly higher than for crossbred rabbits.

2.5. Indicators of Physiological Stress

2.5.1 Skin Temperature

Nakamura *et al*. (1983) defined skin or body temperature as the single most useful measurable parameter and a sensitive indicator of reactions of the animal to environmental factors, disease processes, and physiologic functions such as nutrition, reproduction, and lactation. The skin serves as a receptor for cold or hot temperature, from where nerve impulses are transmitted to the anterior and posterior hypothalamus for heat regulation and conservation, as well as for control of feed consumption and metabolic rate, which is influenced by degree of ambient temperature (Willmer and Johnston 2004). High ambient temperature increased skin temperature of rabbits (Zeferino *et al.,* 2011). Vitamin C resulted in significant decrease in skin temperature of rabbits during the hot dry (Adenkola *et al.,* 2009).

2.5.2 Ear Temperature

Ears of a rabbit occupy 12% of the animal body surface area, are highly vascular and play a vital role in temperature regulation (Lukefahr and Ruiz-feria, 2003), and could be compared to a car radiator (Lebas *et al.,* 1986). During the hot dry season, the animal stretches the ear pinna far from the body to dissipate heat through radiation, convection and evaporation to the surrounding, as a result of this processes the ear temperature increases (Fayez *et al*., 1994), while

in cool wet season the pinna are folded to reduce contact between the internal surface and air movement, and at the same time drag the ear close the body to conserve heat (Fayez *et al*., 1994).

2.5.3 Scrotal Temperature

Exposure of the scrotum to high temperature which normally occurs in the hot dry season leads to destruction of generative cells of the seminiferous tubules and gradually atrophies the interstitial or leydig cells (Vogler *et al.,* 1993). High scrotal temperature has a high degree of seminal degeneration which reduces fertility and increases sperm abnormalities (Vogler *et al.,* 1993).

It also leads to decrease in testis weight, which reduces sperm viability, increases morphological abnormalities and decreases motility of spermatozoa, as well as reduction of testicular blood flow and alteration of vasomotion (Setchell *et al.,* 1995). For efficient spermatogenesis, a temperature range of 2-8^{o}C below the body temperature is required (Banks *et al.,* 2005). High scrotal temperature causes cytoxic effect on some germ cells and is more pronounced in spermatocytes than differentiated spermtogonia (Banks *et al.,* 2005), and alteration of DNA, RNA and proteins as well as protein denature and abnormal chromatin packing and causes sub fertility (Sailer *et al.,*1997).

It also inhibits the functionality of the epididymis which stores and maintains viable spermatozoa Bedford (1991), resulting in the gradual and progressive accumulation of dead, decapitated, immotile spermatozoa (Banks *et al.,* 2005).The antioxidant role of this vitamin has been reported in reducing testicular oxidative stress (Kutlubay *et al.,* 2007).

2.5.4 Rectal Temperature

Rectal temperature is recognized as a vital measure of physiological status as well as a good indicator for a stressed animal or heat storage in the animal body (Lefcourt *et al.,* 1986). Rectal temperature indicates changes in deep body temperature which affect growth, reproduction, and production in animals (Padilla *et al.,* 2006).

Rectal temperature rises as a result of high relative humidity which reduces the efficiency of evaporative cooling coupled with high environmental temperature to overwhelm the capacity of the animal to maintain normal body temperature (Ganaie *et al.,* 2013). High rectal temperature was reported by Iyeghe *et al.* (1993) in weaned rabbit during hot dry season. Adenkola and Ayo (2009) demonstrated that vitamin C reduced the rectal temperature in animals especially during the hot hours of the day and that, it may be of value in combating adverse effects of heat stress in animals during the hot-dry season. Similarly the report of Whitehead and Keller (2003) demonstrated that, vitamin C ameliorates the adverse effect of heat stress by modulating and reducing rectal temperature in a stressed animal. Ayo *et al.* (2011) reported a distinct diurnal fluctuation in rectal temperature of rabbits, in comparison with vitamin C treated group and untreated on road transportation.

Piccione and Caola (2002) showed that vitamin C exerts hypothermic effects by potentiating gamma aminobutyric acid (GABA) which is a powerful inhibitory neurotransmitter in the brain, thus diurnal fluctuations in livestock have been shown to be driven by a biological clock in the brain, particularly in the hypothalamus. In the same manner, Mousa-Balabel (2004) reported that rectal temperature in rabbits group treated with Vitamin C was lower than the untreated group. Saleh (2003) reported that dietary electrolytes significantly reduced rectal temperature of a stressed animal.

2.5.5 Respiratory Rate

Evaporative loss through the respiratory tract is a primary mechanism for heat balance in rabbits and other species of livestock (Ganaie *et al.,* 2013). Increase in respiratory rate arises as a result of direct heat stimulation of the peripheral receptors which transmit nervous impulses to the thermal centre in the hypothalamus **(**Ganaie *et al.,* 2013). The cardio-respiratory center is stimulated to send impulses to the diaphragm and intercostal muscles for further respiratory activity (Razdan *et al.,* 1968).

Respiratory rate is a good measurable indicator for heat stress and it correlate positively with corticoids concentration in circulation, in the blood of a stressed rabbit (Kumar, 2005). Normal respiratory rate is approximately 10-30 breath/minute (Hafez, 1968), respiratory rate increased when ambient temperature increased, because there is a positive relationship between respiratory rate and environmental temperature (Bond and MCDowell, 1972). High respiratory rate in most cases does not show that the animal is successfully keeping its body temperature constant, but rather indicates that the animal is over- heated and trying to restore normal heat balance (McDowell *et al.,* 1976).

Mousa-Balabel (2004) indicated that vitamin C plays an important role in reduction of respiratory rate of animals during heat stress in treated group than untreated group. Correspondently Abdel-Monem *et al.* (2013) reported that there was significant reduction in respiratory rate of rabbits fed 800mg/kg vitamin C over those without vitamin C inclusion in their feed.

2.5.6 Heart Rate

Heart rate is modulated by autonomic nervous and endocrine system, (in different seasons of the year), it decreases when the temperature is low, increase when temperature is high (Leagates *et al.,* 1991). It is one of the physiological parameters that give an immediate response to the climatic stress and consequently, the level of discomfort and comfort of an animal (Leagates *et al.,* 1991). Heart rate response is used to determine the comfort and adaptability to an adverse environmental condition (Sethi *et al.,* 1994).

Ganaie *et al.* (2013) did not report a definite trend of change in heart rate in relation to changes in environmental temperature however, increase in heart rate resulting from increase in environmental temperature was reported by Seath and Miller (1946). Chikamune and Shimizu (1983) reported a negative correlation between air temperature and heart rate in animals. Joshi *et al.* (1982) reported increased heart rate with exposure to hot environment. High environmental temperature increase heart rate and low environmental temperature decrease heart rate and also influences high metabolic rate in animals (Ganaie *et al.,* 2013).

2.6. Semen Characteristics

The influence of season on seminal characteristics of domestic animals reared in temperate regions of the world has been documented (Mahmoud *et al.,* 1996; Penfold *et al.,* 2000). It has been established that tropical environment with high ambient temperatures and low relative humidity have adverse effect on semen quality of livestock (McDonald, 1995). Season had significant influence on increase and depression in quantitative and qualitative parameters of semen (Obidi *et al.,* 2008).

These depressions have been shown to affect fertility and reduced reproduction of animals (Bah *et al.,* 2001). Temperature promotes semen volume and concentration, a subsequent rise suppresses reproductive capacity as a result of a decrease in seminiferous epithelial cell differentiation, which is manifested in decreased semen quality and quantity with time (Mc Danie *et al.,* 1996; Obidi *et al.,* 2008).

2.6.1 Semen Volume

Significant reduction in semen volume of poultry breeder cocks during hot dry season was reported by (Obidi *et al.,* 2008). Nayak and Misra (1991) observed that decrease in sperm production and fertility was caused by hot dry season, characterized by high ambient temperature and humidity. Depression in seminal volume when environmental temperature is outside the zone of thermal comfort of an animal has also been reported by (McDaniel *et al.,* 1996).

The decrease in semen ejaculate volume of rabbit bucks was attributed to effect of high temperature on the level of testosterone production (Tharwat *et al.,* 1994). Al-Ghalban *et al.* (2004) reported a significant decrease in semen volume between March to May with highest volume recorded from June to August. Obidi *et al.* (2008) reported that semen ejaculate volume decreased during the hot dry period of the year which normally occurs within the months of March to May. A rapid increase in semen ejaculate volume from the months of June to August has also been reported by Tharwat *et al.* (1994).

It has been reported that semen ejaculate volume differs significantly among breed (Tawfeek *et al.,* 2010). Tharwat *et al.* (2004), Seleem *et al.* (2008) reported similarly that semen ejaculate volume is breed dependent, and purebred have higher semen ejaculate volume than crossbred. Seleem **(**2005) reported that there is no significant difference in ejaculate volume among breeds.

Yousef *et al.* (2003) indicated that supplementation of 1.5 g ascorbic acid in drinking water reduced the production of free radicals and can improve rabbit semen quality.

2.6.2 Sperm Motility

Sperm motility is one of the vital characteristics of semen quality the wavelike pattern of movement of sperm cells, is grossly reduced by excessive levels of reactive oxygen species which is prevalent during the hot dry season (Agarwal *et al.,* 1999). Influx of intracellular calcium ion plays a vital role in spermatozoa flagella motility and fusion of acrosome vesicles (Armstrong *et al.,* 1999), any interruption of the critical ionic function(s) frustrates viability and fertility (Armstrong *et al.,* 1999). During ejaculation, seminal plasma stimulates spermatozoa motility and guaranties protection against negative influence of environmental factors (Castellini, 2008). Al-Ghalban *et al.* (2004) reported highly significant decrease of sperm motility from the month of March to May and increase from the month of June to August. Also Boland *et al.* (1985) reported that sperm motility increased steadily from April to August. Sperm motility varies among breeds of animals with the higher values in purebred than crossbred, this variation may be due to the differences in pituitary gland activity that can affect the secretion of luteinizing hormone which affects the secretion of testosterone from the interstitial tissue of the testes and there is a significant positive correlation between the sperm motility and fertility in rabbits (Seleem 2005). Azawi *et al.* (2012) reported that semen diluted with Tris diluent containing vitamin C improved sperm motility and viability.

The addition of vitamin C did not only improve sperm viability but also protected acrosome and membrane integrity (Hughes *et al.,* 1998). Asadpour *et al. (*2011) also reported that semen motility was significantly higher in samples extended with 1 mM and 2 mM vitamin C compared with the control group. Ezzat *et al.* (2011) found that supplementation of vitamin C in diets of

animals under hot dry condition significantly increased sperm motility. The adverse effect of heat stress on spermatogenic processes is shown in decreased number of spermatozoa in the ejaculate, which is of great importance in male fertility (Marai *et al.,* 2002).

Vitamin C has positive influence on spermatozoa motility (Marai *et al.,* 2002), though the effect appears to be variable with level of supplementation. Metwally and Fouad (2009) reported that the higher the vitamin C level of inclusion in diet the higher the sperm motility obtained. Hassan *et al. (*2012) reported an increase in sperm motility of rabbit bucks fed 250mg/kg vitamin C supplement and low semen motility in bucks without vitamin C supplement. Fazeli *et al.* (2010) reported a significant increase in sperm motility in animals fed both 20mg/kg and 40mg/kg vitamin C over the non-vitamin C treatment. However, Abel *et al.* (1983) reported that higher dosages of vitamin C may have damaging effects on pro-oxidants which actually reduce sperm motility.

2.6.3 Semen pH

Semen pH is a major factor for sperm development, external factors like ambient temperature play a key role in semen pH (Billard *et al.* 1995). Activation of sperm cells is pH dependent (Billard, 1983). High environmental temperatures increase pH values of semen (Finzi *et al.,* 2000; Boulbina *et al.,* 2012). There is a positive correlation between semen pH and primary, secondary, tertiary spermatozoa abnormalities and litter size of rabbits (Eiben, 2000).

El-Tohamy *et al.* (2012) reported a significant decrease in hydrogen ions of semen at high ambient temperature than low ambient temperature. Salah *et al.* (1992) reported a significant seasonal variation in semen pH during hot dry and cool wet periods of the year. Vitamin C reduced semen pH in animals compared to un-administered animals which expressed high pH

values, however, graded levels of vitamin C did not significantly affect semen pH though the higher the dosage the higher semen pH values expressed (Fazeli *et al.,* 2010).

2.6.4 Semen Concentration

Decrease in semen concentration during hot dry period of the year in rabbits and other species of livestock have been reported by Nizz *et al.* (2003). This could be linked to the degeneration of germinal epithelium and partial atrophy of the seminiferous tubules (Marai *et al.,* 1991; Kridli *et al.,* 2007). There are contrary reports that semen concentration is not affected by ambient temperature and humidity or stress (El-Tohamy *et al.,* 2012). Significant variations in semen concentration among breeds of rabbit have been reported with higher values recorded in purebred than crossbred rabbit bucks (Seleem, 2005; Seleem *et al.,* 2008).

The variation in the sperm cell concentration may be due to difference in testosterone level, the body size and testicular weight (Seleem *et al.,* 2005, 2008). El-Tohamy *et al., (*2010) reported that semen concentration is highly increased by vitamin C by decreasing the inhibitory effect of lead acetate on semen. However Asadpour *et al.* (2011) observed non-significant effect of vitamin C level on semen concentration although Metwally and Fouad (2009) and Fazeli *et al.*(2010) reported that sperm concentration increased with an increase in vitamin C inclusion level. Ralston *et al.* (1988) reported that vitamin C supplementation in sub–fertile animals increased plasma and semen concentration as well as resulting in improved fertility. Sonmez and Demirci (2003) reported that intramuscular injection of 20 mg ascorbic acid per kg live weight for 30 days increased seminal plasma.

2.6.5 Semen Colour

Ambient temperature influenced changes or variation in semen colour from creamy to milky and watery, which occurred during hot dry season to cool wet season of the year (Rai *et al.,* 1997).

The variations in semen colour in different seasons of the year could be attributed to the variation in spermatozoa concentration and semen consistency (Zeidian *et al.,* 2000). However, Salah *et al.* (1992) reported that the ranges of semen ejaculate colour from light milky to creamy, with majority being milky white, was not season dependent.

2.6.6 Live and Dead Sperm Ratio

El-Tohamy *et al.* (2012) reported a significant adverse effect of heat stress on live sperm, with increase in percentage of dead sperm in rabbit semen reared in the hot dry season. This may be due to spermatozoa susceptibility to oxidative stress that increase during the period of heat stress (Aitken and Fisher, 1994).

The increase in dead spermatozoa of rabbit bucks during the hot dry season may be due to the adverse effect of heat stress on epididymal function which is under the control of testosterone that is affected negatively by heat stress (Marai *et al.,* 1998). Salah *et al.* (1992) also observed an appreciable increase in the percentage of dead spermatozoa during the hot dry season and increase in live spermatozoa during the cool wet season in male animals. Crossbred rabbit bucks had higher live sperm percentage and lower dead sperm per ejaculate than pure bred bucks which had higher dead sperm and lower live sperm (Khalil, 1996). Significant increase in dead sperm cells was observed in purebred rabbits than crossbred (Seleem *et al.*, 2008).

Tomar *et al*. (1979) reported that the addition of ascorbic acid to liquid extenders resulted in an increase of live spermatozoa percentage and fertility. Fazeli *et al.* (2010) Similarly, Hassan *et al.*(2012) reported that supplementation with dietary or oral vitamin C increased live spermatozoa and decreased dead sperm ratio in rabbit bucks under heat stress. While oral

administration of 1.5 g vitamin C reduced dead spermatozoa count in rabbit bucks (Ezzat *et al.*, 2011).

2.7 Sperm Morphology and Abnormalities

Spermatozoa morphology is an important parameter in the fertilization process *in vivo* and *in vitro*. It can be used as a single and independent predictor for successful fertilization (Chenoweth, (2005). High ambient temperature increased the rate of sperm abnormalities, affect spermatogenesis, and the last stage of differentiation of spermatids (Boulbina *et al.*, 2012). Banaszewska *et al.* (2007) reported that there is dependence between morphology of spermatozoon and the length of the day; the longer the day, the more normal spermatozoa morphology is observed in semen.

Abnormal spermatozoa morphology is often observed during the hot dry season, and may reduce fertility in the following ways: (i) failure to reach the fertilization site, (ii) inability to fertilize the ovum once they are at the fertilization site, and (iii) inability to sustain development of the early embryo (Chenoweth, (2005). Seleem *et al.* (2008) reported that high degree of sperm abnormalities were recorded in purebred than crossbred rabbits. Low levels of vitamin C in mammals increased abnormal sperm morphology, reduced fertility, and decreased agglutination (Dawson, 1990).

A balance normally exists between reactive oxygen species production and antioxidant scavenging activities in the male reproductive tract. As a result of such balance, only minimal amounts of reactive oxygen species remain, and they are needed for the regulation of normal sperm functions, such as the acrosome reaction, sperm capacitation, and sperm–oocyte fusion (Aitken, 1999).Mangoli *et al.* (2012) reported that high level of vitamin C improved sperm

quality while low level increased occurrence of sperm abnormalities, and the increase in normal sperm was recorded in the vitamin C group than the non-vitamin C group. Vitamin C decreased the incidence of secondary sperm abnormalities by reducing free radical formation (Sikka, 1996).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Experimental Site

The study was conducted in the Rabbitry of the National Animal Production Research Institute (NAPRI), Shika, Zaria. Shika is located in the Northern Guinea Savanna, on latitude 11^{o}12'N of the equator and longitude 7^{o}33'E with an altitude of about 610m above sea level. Morning temperatures ranged between 19^{o}C and 32^{o}C, while afternoon temperatures ranged between 20^{o}C and 38^{o}C. The cool season or the early dry season falls within the months of October and February while the hot season or late dry season falls within the months of March and May, while the cool wet season falls within the months June to September.

3.2 Experimental Animals and Management

A total 40 purebred of New Zealand White (NZW) and 15 crossbred New Zealand White x California white (NZW×CAL) bucks (10 months old) were used for this study which lasted for seven months. The rabbits were weighed and kept individually in metal cages, in a 2×2×4 factorial arrangement in a completely randomized design (two breed, two seasons and four vitamin C levels). The dimensions of the metal cages were 60 x 60 x 50 cm, placed in a well-ventilated house; with 5ft walls, covered with wire netting, and roofed with zinc sheet. Feed grade vitamin C was obtained from Hybrid feed and included in the concentrate feed shown in table 3.1at varying levels of 100 control, 200, 300 and 400mg/kg feed. Feed and water were provided *ad libitum.*

3.3 Data Collection

Performance record

The animals were weighed at the beginning of the experiment and fortnightly. Thereafter data on the following parameters were collected (1) Feed intake: 200 mg of feed was weighed using calibrated scale of 25g to 1kg. Feed was provided at 7.00am daily to the animals and the left over feed was weighed using the same scale the next day. (2) Water intake: 500 ml water was measured using calibrated cylinder of 10ml to 1000ml. water was provided at 7.00am to the animals the left over water was measured using the cylinder the next day.(3) Weight gain was measured using calibrated scale of 50g to 20 kg fortnightly.

Determination of Thermoregulatory parameters:

Data were collected between 9.00 am and 10.00am fortnightly throughout the experimental period of seven month on skin, rectal, ear and scrotal temperatures using a digital thermometer, while respiratory rate and heart rate were determined using a stop watch and stethoscope. The skin temperature was measured by placing the sensitive point of the digital thermometer on the neck region of the rabbit. The ear temperature was measured by placing the sensitive point of the digital thermometer on the ear. Rectal temperature was measured by inserting the sensitive unit of the digital thermometer in the rectum approximately 1cm depth.

Scrotal temperature was measured by placing the sensitive unit of the digital thermometer on the scrotum. Respiratory rate was determined while the rabbit was resting by visually counting the flank movements for one minute using a stop watch. Heart rate was measured using a stop watch and stethoscope; the stethoscope was placed on the left region of the thoracic vertebrae of the rabbit and a stop watch was used to count the heart rhythms for one minute. Scrotal circumference and diameter was measured using thread and a 30cm calibrated ruler; the thread

was put round the left and right scrotal sac and then placed on the ruler to take readings, this was done independently. The scrotal diameter was measured in the same way, but the thread was put in an arc form.

Semen collection and analysis:

Semen was collected fortnightly between 9.00 am and 10.0 am. A doe was used to tease the bucks and then semen was collected using artificial vagina. Each of the ejaculate was examined for the following parameters: 1. Physiological characteristics: volume, concentration, progressive motility, live sperm, dead sperm, pH, colour, 2. Abnormalities which include: normal and abnormal sperm, tailless head, rudimentary tail, bent tail, coiled mid piece, bent mid piece, coiled tail, round cell, dag defect, proximal droplet, stump tail, round cell, dag defect, pyriform, ruffle acrosome, translocating cytoplasmic droplet, tail opening droplet translocation, double head, neck and flagellum, double head single neck and flagellum.

The semen ejaculate volume was measured using 4ml calibrated collection tube immediately after collection of semen. Sperm motility was determined on freshly collected semen placed on clean slid covered with a cover slip and viewed under a microscope at magnification of ×400. Sperm concentration was determined using haemocytometer and Thoma-Zeiss cell counter. The haemocytometer had microscopic grids which contained 25 large squares; each of the squares had 16 smaller squares which make a total of 400 squares. Sperm cells were counted diagonally from top left to bottom right, from top right to bottom left and on the middle to make a total of five counts from large grids (Hafez,1986).

Morphology of sperm cells, dead and live sperm was viewed in stained slides under a microscope at magnification of ×100 (Hafez, 1986). Stain was prepared by dissolving 10.0g

nigrosine and 1.67g eosin in 100ml distilled water. A Pasteur pipette was used to take a drop of fresh semen and a drop of stain then placed on the slide, a smear was made the slide was allowed to dry in a current of warm air for 20 minutes at 37^{o}C and viewed under a microscope at magnification of ×100, all sperm cells that picked the stain were considered alive while the dead sperm do not. pH (hydrogen ion concentration) value was measured using Chemo craft indicator paper, the pH indicator paper was commensurate from 1 to 14 with various colours showing the pH.

A part of the indicator paper was immersed in the semen, removed and placed on the colour chart; the corresponding colour was recorded as the pH value. Semen colour was observed immediately after semen collection. Total sperm output was determined by multiplying the semen ejaculate volume by sperm cell concentration. Reaction time was measured to note the sexual drive, by using a stop watch. Libido scoring pattern of 1-5(no libido-high libido) was as described by Chibundu (2005).

3.4 Statistical Analysis

The data generated from study were statistically analyzed using the General Linear Model procedure of Statistical Analysis System (SAS, 2002); significant differences between means were separated by pair wise difference (pdiff). The model used was as follows:

$$Y_{ijklm=}\mu + T_i + B_j + S_k + (T_i \times B_j) + (T_i \times S_k) + (S_k \times B_j) + e_{ijkml}$$

Where Y_{ijklm} = Response variable

μ = Overall Mean.

T_i = Fixed effect of i^{th} Treatment (i=100 control, 200, 300, 400 mg vitamin C level)

B_j = Fixed effect of j^{th} Breed (j= Pure and Crossbred)

S_k = Fixed effect of k^{th} Season (k=Hot dry and Cool wet)

$T_i \times B_j$ = Fixed Interaction effect between i^{th}Treatment (100 control, 200, 300, 400 mg vitamin C levels) and jth Breed

$T_i \times S_K$ = Fixed Interaction effect between i^{th} Treatment (100 control, 200, 300, 400 mg vitamin C levels) and k^{th} Season

$B_j \times S_k$ = Fixed Interaction effect between j^{th} Breed and k^{th} Season

e_{ijkl} = random residual error

$Y_{ijklm} = \mu + T_i + B_j + M_l + (T_i \times M_l) + (B_j \times M_l) + (T_i \times B_j) + (T_i \times S_k) + e_{ijkml}$

Where Y_{ijklm} = Response variable

μ = Overall Mean.

T_i = Fixed effect of i^{th} Treatment (i=100 control, 200, 300, 400 mg vitamin C level)

B_j = Fixed effect of j^{th} Breed (j= Pure and Crossbred)

M_l = Fixed effect of l^{th} Month (l=March- September)

$T_i \times M_l$ = Fixed Interaction effect between i^{th}Treatment (100 control, 200, 300, 400 mg vitamin C levels) and l^{th}Month

$B_j \times M_l$ = Fixed Interaction effect between j^{th}Breed and l^{th}Month

$T_i \times B_j$ = Fixed Interaction effect between i^{th}Treatment (100 control, 200, 300, 400 mg vitamin C levels) and j^{th}Breed

$e_{ijk\,l=}$ random residual error

Table 3.1: Feed Composition Table

Ingredient	%
Maize	45
GNC	35
Maize Offal	15
Bone meal	3
Salt	0.25
Vitamin/Minerals premix	0.25
Total	98.5
Calculated Analysis	
Energy(kcal ME/Kg)	2687.74
CP	20
CF	4.17
Ash	2.68

Vitamin/mineral premix content per kilogram ration: vitamin A1251IU, vitamin D32750IU, vitamin E 151IU, vitamin B2 0.006g, Nicotinic acid 0.035g, Calcium D-pantothenate 0.01mg, vitamin B6 0.035g, vitamin B12 0.02g, folic acid 0.001, Biotin 0.0003g, vitamin C 0.0025g,choline choride 0.39, Zinc bactracin 0.002g,methionine 0.2g, Avatee(Lasolocid) 0.09g, manganese 0.1g, Iron 0.05g, Zinc 0.04g, Copper 0.002g, Iodine 0.00153g, cobalt 0.00025g, Selenium 0.0001g.

CHAPTER FOUR

4.0 RESULTS

4.1 Average Monthly Ambient Temperature and Ambient Relative Humidity during the Study Period

Figure 1 shows the average monthly ambient temperature and ambient relative humidity during the study period. Morning temperature increased from the month of January to May, and decreased from the month June to December. Afternoon temperature decreased from to January to February, increased from the month of March to April, decreased in the month of May to September, increased in October, and decreased in the month of November and December. The ambient relative humidity of morning and afternoon decreased and increased in the same pattern, the ambient relative humidity of morning and afternoon decreased from January to February, and increased from the month of March to October, then decreased from November to December.

4.2 Effect of Vitamin C level on Growth Performance of Rabbit Bucks

Table 4.1 shows effect of vitamin C levels on performance of rabbit bucks. There was no significant difference on final weight, weight gain, reaction time, left scrotal circumference and average daily gain across vitamin C levels. There was significant increase ($p<0.01$) in feed intake across vitamin C levels, with higher feed intake recorded for bucks fed 400 mg vitamin C. Water intake was highly significantly ($p<0.01$) different across vitamin C levels, with higher water intake recorded for bucks fed 400 mg vitamin C. Right scrotal circumference of rabbits at 400 mg vitamin C level was significantly ($p<0.01$) higher than bucks on 100, 200, and 300 mg/kg vitamin C levels.

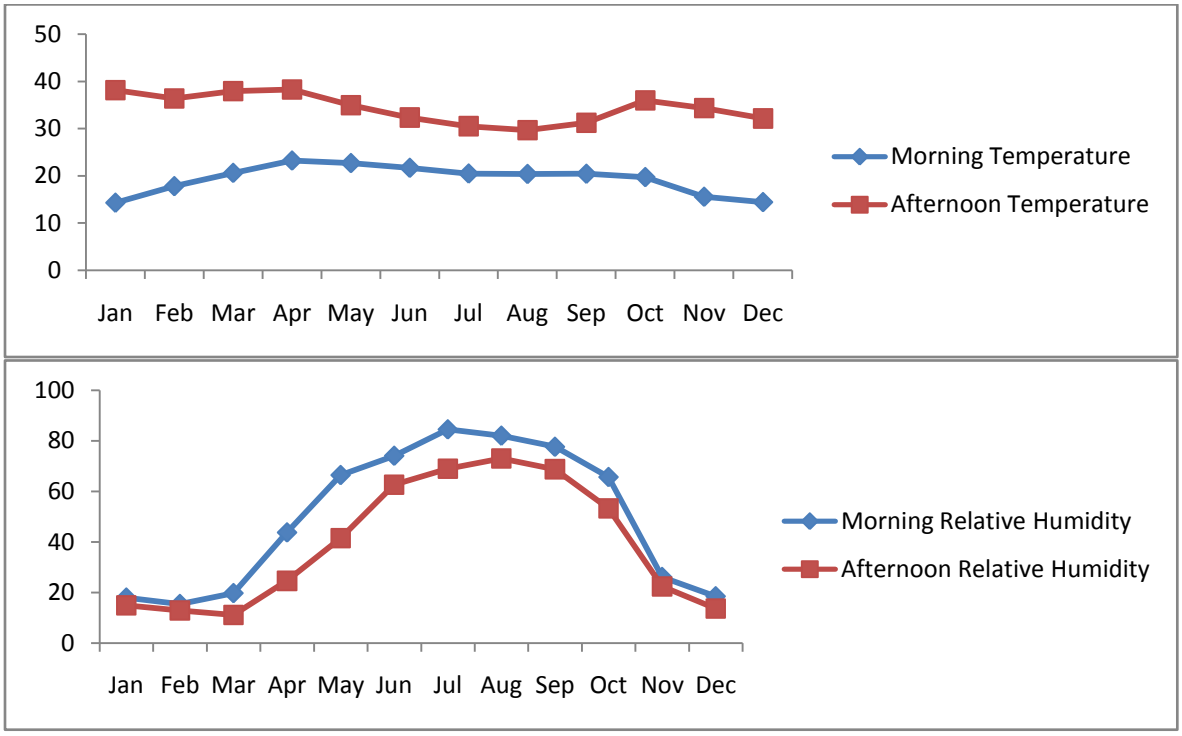


Figure 1: Average Monthly Temperatures and Humidity during the Study Period.

Table 4.1: Effect of Vitamin C levels on Growth Performance of Rabbit Bucks

Parameters	Vitamin C(mg/kg feed) 100	200	300	400	p-v
Initial weight(kg)	3.58±0.06	3.69±0.09	3.52±0.09	3.67±0.09	0.52
Final weight(kg)	3.42±0.09	3.49±0.10	3.46±0.09	3.73±0.10	0.12
Feed intake(g/day)	121.57±2.65^{c}	124.42±2.91^{b}	113.40±2.6^{d}	131.27±2.99^{a}	0.0001
Water intake(ml/day)	321.08±5.03^{b}	307.95±5.52^{d}	315.18±5.06^{c}	338.09±5.67^{a}	0.001
Weight gain(g)	-157.07±72.49	-200.00±80.06	-60.76±73.09	60.42±78.51	0.094
Average daily gain (g)	-1.75± 0.81	-2.22±0.89	-0.68±0.81	0.67±0.87	0.094
Scrotal circumference(cm):					
Left	5.67±0.06	5.55±0.07	5.64±0.06	5.77±0.06	0.06
Right	5.66±0.06^{b}	5.51±0.065^{b}	5.66±0.06^{b}	5.94±0.06^{a}	0.0001
Reaction time (s)	4.84±0.40	3.93±0.41	4.05±0.42	4.62±0.46	0.3

Means along a row with different superscript letters are significantly different ($p<0.01$). Reaction time: The time it took a buck to sniff, groom and mount a doe

4.3 Effect of Breed on Growth Performance of Rabbit Bucks Fed Diets Supplemented with Vitamin C

Table 4.2 shows the effect of breed on growth performance of rabbit bucks fed diets supplemented with vitamin C. There was no significant difference in initial and final weight among breed of bucks. Significant ($p \leq 0.05$) difference however was observed in feed intake among breeds of bucks with higher intake in crossbred than purebred bucks. Water intake in purebred bucks was significantly ($p \leq 0.05$) higher than for the crossbred bucks. Left scrotal circumference in purebred was significantly ($p < 0.05$) higher than in crossbred bucks however, there was no significant difference on right scrotal circumference among the breeds. Response time of purebred bucks was significantly ($p \leq 0.01$) longer than for crossbred bucks.

4.4 Effect of Season on Growth Performance of Rabbit Bucks fed Vitamin C Supplemented Diets

Table 4.3 shows effect of season on performance of rabbit bucks fed diets supplemented with. The final weight at cool wet was significantly ($p \leq 0.01$) higher than hot dry season. There were highly significant ($p \leq 0.001$) differences in weight gain and average daily gain, being higher at cool wet than hot dry season. Feed intake at cool wet was highly significantly ($p < 0.01$) higher than hot dry season. Water intake at hot dry was highly significantly ($p < 0.01$) higher than cool wet season. The left and right scrotal circumference at cool wet season were highly significantly ($p < 0.01$) higher than hot dry season.

Table 4.2: Effect of Breed on Growth Performance of Rabbit Bucks Fed Vitamin C Supplemented Diets

Parameters	Pure	Cross	p-v
Initial weight(kg)	3.55±0.05	3.66±0.08	0.30
Final weight(kg)	3.48±0.05	3.56±0.08	0.63
Feed intake(g/day)	119.9±1.49[b]	125.42±2.38[a]	0.05
Water intake(ml/day)	326.13±2.83[a]	315.01±4.51[b]	0.03
Weight gain(g)	-73.32±33.74	-98.88±51.27	0.54
Average daily gain(g/day)	-0.81±0.37	-1.10±0.57	0.54
Scrotal circumference(cm):			
Left	5.72±0.03[a]	5.59±0.05[b]	0.04
Right	5.69±0.03	5.68±0.05	0.9
Reaction time (s)	4.66±0.24[a]	3.47±0.39[b]	0.01

Means along rows with different superscript letters are significantly different ($p<0.05$). Reaction time: The time it took a buck to sniff, groom and mount a doe

Table 4.3: Effect of Season on Growth Performance of Rabbit Bucks Fed Vitamin C Supplemented Diets

Parameters	Hot Dry	Cool Wet	p-v
Initial weight(kg)	3.66±0.06	3.54±0.06	0.08
Final weight(kg)	3.42±0.07[b]	3.61±0.07[a]	0.01
Feed intake (g/d)	105.81±1.58[b]	140.77±1.77[a]	.0001
Water intake(ml/d)	350.93±3.09[a]	286.23±3.47[b]	.0001
Weight gain(g)	-239.96±42.28[b]	67.75±44.50[a]	.0001
Average daily gain(g/day)	-2.67±0.47[b]	0.75±0.49[a]	.0001
Scrotal circumference(cm)			
Left	5.51±0.04[b]	5.83±0.05[a]	.0001
Right	5.59±0.04[b]	5.80±0.05[a]	0.001
Reaction time(s)	4.72±0.30	4.00±0.30	0.09

Means along a row with different superscripts letters are significantly different ($p<0.01$).Reaction time: The time it took a buck to sniff, groom and mount a doe

4.5 Effect of Month on Growth Performance of Rabbit Bucks Fed Diets Supplemented with Vitamin C

Table 4.4 shows effect of month on performance of rabbit bucks fed diets supplemented with vitamin C. Month had a highly significant effect on performance of rabbit bucks. There was significant decrease in the live weight of rabbit bucks ($p<0.01$) during the month of March to April but increased significantly from the months of June to August with the higher weight gain recorded in July and August. Water intake of rabbit bucks decreased significantly ($p<0.01$) from the month of March through August. The highest water intake was recorded in the month of March. There was a significant increase ($p<0.01$) in feed intake across month except in the month of April in which there was a decline. During the months of March to April there was significant ($p<0.01$) decline in weight gain by the bucks. However from June to August bucks weight gain increased significantly ($p<0.01$), with the highest gain recorded in July. There was significant ($p<0.01$) difference in both left and right scrotal circumference across months the largest left scrotal circumference (6.02 cm) was recorded in September followed by (5.93 cm) in the month of June. Similarly, the largest right scrotal circumference (5.99 cm) was recorded in the month of September followed by (5.92 cm) in August. There was significant ($p<0.01$) high variation in response time across months. The shortest response time (3.55 s) was recorded during the month of June while the longest response time (6.02s) was recorded in September.

The research was stop by NAPRI in September that caused missing data.

Table 4.4: Effect of Month on Growth Performance of Rabbit Bucks Fed Vitamin C Supplemented Diets

Parameters	March	April	May	June	July	August	Sept	p-v
Live weight (kg)	3.59±0.07^{b}	3.40 ±0.06^{d}	3.42 ± 0.06^{d}	3.55±0.07^{c}	3.66 ±0.07^{a}	3.66 ±0.07^{a}		0.013
Water intake (ml/d)	413.60± 4.14^{a}	334.83±5.20^{a}	281.43±4.8^{e}	282.65±5.4^{e}	291.10± 5.44^{c}	285.36±4.87^{d}		.0001
Feed intake (g/d)	108.25±2.37^{e}	89.72±2.98^{f}	116.14±2.76^{d}	126.69±3.10^{c}	140.07±3.12^{b}	152.80±2.79^{a}		.0001
Weight gain (g)	-1.99±1.22^{f}	-5.26±1.16^{d}	-4.86 ±1.16^{e}	0.004 ±1.22^{c}	4.80 ±1.22^{a}	0.31±1.22^{b}		.0001
Scrotal Circumference(cm):								
Left	5.57±0.07^{e}	5.58±0.06^{e}	5.62 ±0.08^{d}	5.93 ±0.08^{b}	5.46±0.08^{f}	5.89 ±0.08^{c}	6.02±0.11^{a}	.0001
Right	5.61±0.07^{e}	5.66±0.06^{d}	5.67± 0.07^{d}	5.87 ±0.08^{c}	5.37±0.08^{f}	5.92±0.08^{b}	5.99±0.11^{a}	.0001
Reaction Time	4.96±0.66^{c}	3.65 ±0.48^{f}	5.77±0.42^{b}	3.59 ±0.38^{g}	4.62±0.84^{d}	4.59 ±0.65^{e}	6.02±0.11^{a}	0.0045

Means along a rows with different superscripts letters are significantly different ($p<.0.01$). Reaction time: The time it took a buck to sniff, groom and mount a doe

4.6 Effect of Interaction between Vitamin C levels and Breed on Growth Performance of Rabbit Bucks

Table 4.5 shows effect of interaction between vitamin C levels and breed on growth performance of rabbit bucks. There were no interaction between vitamin C levels and breed in initial and final weight, weight gain, average daily weight gain and reaction time. There was interaction between vitamin C levels and breed on feed intake ($p<0.05$) of the rabbits. Feed intake was higher in crossbred than purebred rabbits on 100, 200 and 400 mg vitamin C but similar feed intake was recorded in pure and crossbred rabbits fed 300 mg/kg vitamin C. There was interaction between vitamin C levels and breed on water intake ($p<0.01$). Purebred bucks fed 100 and 400 mg vitamin C has higher water intake than crossbred, while crossbred fed 200 and 300 mg has higher water intake than purebred bucks.

There was interactions between vitamin C levels and breed on left scrotal circumference ($p<0.05$). Left scrotal circumference larger in purebred fed 100, 200 and 400 mg vitamin C than crossbred, but left scrotal circumference of crossbred fed 300 mg vitamin C was larger than purebred. There was interaction between vitamin C levels and breed on right scrotal circumference ($p<0.01$). Right scrotal circumference was larger in purebred fed 100, 200 and 400 mg/kg vitamin C than crossbred, but, right scrotal circumference of crossbred fed 300 mg vitamin C was larger than purebred.

Table 4.5: Effects of Interaction between Vitamin C levels and Breed on Growth Performance of Rabbit Bucks

Parameters	100		200		300		400		p-v
	Pure	Cross	Pure	Cross	Pure	Cross	Pure	Cross	
Initial weight(kg)	3.47±0.09	3.69±0.14	3.65±0.09	3.73±0.66	3.37±0.10	3.67±0.14	3.78±0.12	3.56±0.14	0.20
Final weight (kg)	3.36±0.10	3.49±0.16	3.50±0.10	3.47±0.18	3.35±0.10	3.57±0.16	3.80±0.13	3.66±0.16	0.56
Feed Intake(g)	114.7±2.9^{c}	128.4±4.5^{b}	116.5±2.9^{c}	132.3±5.1^{b}	111.2±2.3	115.6±4.5^{c}	137.2±3.3^{a}	125.3±5.0^{b}	0.003
Water Intake (ml)	348.1±5.5^{b}	294.1±8.5^{d}	289.9±5.4^{d}	326.0±9.7^{b}	296.2±5.6^{d}	334.2±8.5^{c}	370.4±6.2^{a}	305.8±9.5^{bc}	0.001
Weight Gain(g)	-7.89±78.92	-206.3±121.6	-150.±76.92	-250.0±140.4	-27.8±81.08	-93.75±121.6	20.83±99.3	100.00±12	0.83
Average daily gain(g/day)	-1.20±8.8	-2.29±1.35	-1.67 ±0.86	-2.78±1.56	-0.31 ±0.9	-1.04±1.35	0.23 ±1.10	1.11± 1.35	0.83
Scrotal circumference(cm)									
Left	5.86± 0.07^{a}	5.47± 0.11^{c}	5.68± 0.07^{b}	5.41± 0.12^{c}	5.53± 0.07^{cb}	5.75± 0.10^{ab}	5.85± 0.08^{a}	5.69± 0.10^{b}	0.005
Right	5.85± 0.06^{ab}	5.46± 0.10^{c}	5.53± 0.06^{bc}	5.50± 0.11^{c}	5.44± 0.07^{d}	5.87± 0.10^{ab}	6.05± 0.08^{a}	5.83± 0.1^{ab}	.0001
Reaction Time (s)	5.65±0.47	3.21±0.74	3.84±0.48	4.03±0.70	4.25±0.48	3.39±0.90	4.91±0.53	3.243±0.79	0.17

Means along a row with different superscript letters are significantly different ($p<0.05$). Reaction time: The time it took a buck to sniff, groom and mount a doe

4.7 Effect of Interaction between Vitamin C levels and Season on Growth Performance of Rabbit Bucks

Table 4.6 shows the effect of interaction between vitamin C levels and season on performance of rabbit bucks. There were no interactions between vitamin C levels and season ($p>0.05$) on initial and final weight, final Feed intake, water intake, weight gain, left and right scrotal circumference.

4.8 Effect of Interaction between Vitamin C levels and Month on Growth Performance of Rabbit Bucks

Figure 2 shows the effect of interaction between vitamin C levels and month on growth performance of rabbit bucks. There were no interaction between vitamin C levels and month in live weight, final weight, and feed intake. There was significant interaction between vitamin C levels and month on weight gain ($p<0.01$) of rabbit. Weight gain of bucks was generally low in months of March, April, and May, and increases in June, a uniform higher weight gain was obtained in month of July, and decreases in August in all vitamin C levels.

There was interaction between vitamin C levels and month on water intake ($p<0.05$). Water intake of bucks was high in the month of March, decline in the months of April and May however, water intake in months of June, July and August was relatively low and uniform at all vitamin C levels**.** There were significant interaction between vitamin C levels and month on reaction time ($p<0.01$). Reaction time fluctuate generally as the month of the year changes, however response time was longer in March at 100 mg/kg vitamin C, and shorter in March at 400 mg/kg vitamin C.

Table 4.6: Effect of Interaction between Vitamin C levels and Season on Growth Performance of Rabbit Bucks

Parameters	100		200		300		400		p-v
	Hot Dry	Cool Wet	Hot Dry	Cool Wet	Hot Dry	Cool Wet	Hot Dry	Cool Wet	
Initial weight (kg)	3.57±0.10	3.5000±0.11	3.78±0.10	3.53±0.12	3.51±0.114	3.42±0.11	3.79±0.13	3.60±0.13	0.8
Final weight kg)	3.25±0.12	3.5615±0.12	3.38±0.12	3.63±0.13	3.342±0.120	3.49±0.120	3.66±0.137	3.84±0.14	0.91
Feed intake (g)	103.62±3.05	137.31±3.38	105.04±3.06	140.46±3.35	96.98±3.10	131.16±3.4	117.60±3.43	154.2±3.88	0.97
Water Intake (ml)	366.35±5.95	290.39±6.6	324.16±6.0	264.05±6.89	331.3±6.06	279.18±6.64	382.03±6.70	311.30±7.57	0.25
Weight Gain (g)	-321.43±75.64	61.54±78.5	-400.±75.64	91.67±81.70	-169.2±78.5	73.08±78.5	-135.0±89.5	240.0±89.50	0.07
Average daily gain(g/day)	-3.57±0.84	0.68±0.87	-4.45±0.84	1.018±0.91	-1.88±0.72	0.812±0.87	-1.501±1.00	2.67±1.00	0.5
Scrotal Circumference(cm)									
Left	5.629±0.08	5.89±0.08	5.49±0.08	5.77±0.09	5.44±0.08	5.77±0.08	5.80±0.09	5.77±0.09	0.16
Right	5.63±0.08	5.86±0.08	5.45±0.08	5.60± 0.08	5.52±0.08	5.62±0.08	5.96±0.09	5.97±0.09	0.63
Reaction Time(s)	5.90±0.53	3.78±0.60	3.81±0.51	4.04±0.63	3.75±0.61	4.35±0.58	5.41±0.74	3.83±0.55	0.06

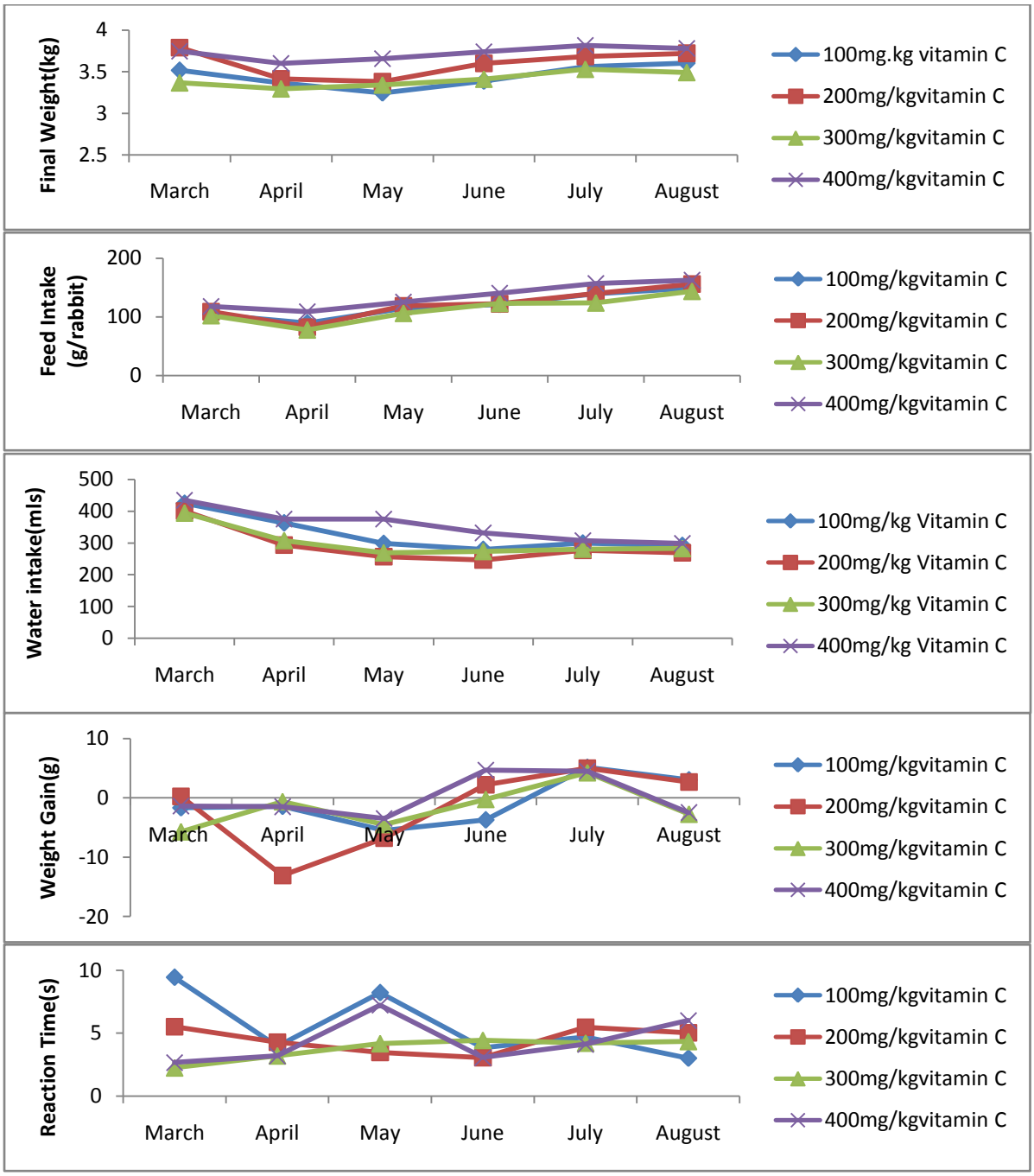


Figure 2: Effect of Interaction between Vitamin C levels and Month on Performance of Rabbit Bucks

4.9 Effect of Interaction between Breed and Season on Growth Performance of Rabbit Bucks Fed Vitamin C Supplemented Diets.

Table 4.7 shows the effect of interaction between breed and season on growth performance of rabbit bucks fed diets supplemented with vitamin C. There was no interaction between breed and season on initial and final weight, feed intake, water intake, and reaction time ($p>0.05$). There was interaction between season and breed on weight gain ($p<0.05$). Purebred had higher weight gain at cool wet season than crossbred. There were significant interactions between breed and season on left scrotal circumference ($p<0.01$) and right scrotal circumference ($p<0.05$). Purebred had larger left and right scrotal circumference in cool wet season than crossbred.

4.10 Effect of Interaction between Month and Breed on Growth Performance of Rabbit Bucks

Figure 3 shows the effect of interaction between month and breed on growth performance of rabbit bucks. There were no interactions between month and breed on live weight, left scrotal circumference and reaction time. There were interaction between month and breed on weight gain ($p<0.01$).Weight gain of breeds was low in the months of March, April and May, and increased in months of June and July, and uniformly decreased in August. There were interaction between month and breed on feed and water intake ($p\leq0.01$). Feed intake of breeds was high months of May to August. Water intake was higher in the months of March and April. There was interaction between month and breed on right scrotal circumference ($p<0.05$). Scrotal circumference of breeds was smaller through the months of March to July, and large through months of June to September.

Table 4.7: Effect of Interaction between Breed and Season on Performance of Rabbit Bucks Fed Diets Supplemented with Vitamin C.

	Pure		Cross		
Parameters	Hot- Dry	Cool- Wet	Hot -Dry	Cool -Wet	p-v
Initial weight(kg)	3.65±0.07	3.45±0.07	3.68±0.10	3.64±0.011	0.4
Final weight(kg)	3.33±0.07	3.62±0.08	3.51±0.11	3.64±0.12	0.3
Feed intake(g)	102.42±1.89	139.13±2.09	112.14±3.0	142.09± 3.41	0.20
Water intake(ml)	350.25± 3.74	290.21± 4.14	347.32± 5.86	271.50±6.76	0.13
Weight gain(g)	-314.29±47.36	167.65±48.06	-165.63±70.05	-32.14±74.89	0.006
Average daily gain(g/day)	-3.493±0.53	1.863±0.53	-1.841±0.78	-0.36±0.83	0.006
Scrotal circumference(cm)					
Left	5.51±0.04^{d}	5.83± .05^{a}	5.72±0.04^{b}	5.69± .055^{c}	.0001
Right	5.59± 0.04^{c}	5.80± .07^{a}	5.69± .035^{b}	5.68± 0.05^{b}	0.003
Reaction Time (s)	5.09±0.34	4.22+0.35	3.57+0.54	3.43+0.6	0.2

Means along rows with different superscript letters are significantly different ($p<0.05$). Reaction time: The time it took a buck to sniff, groom and mount a doe

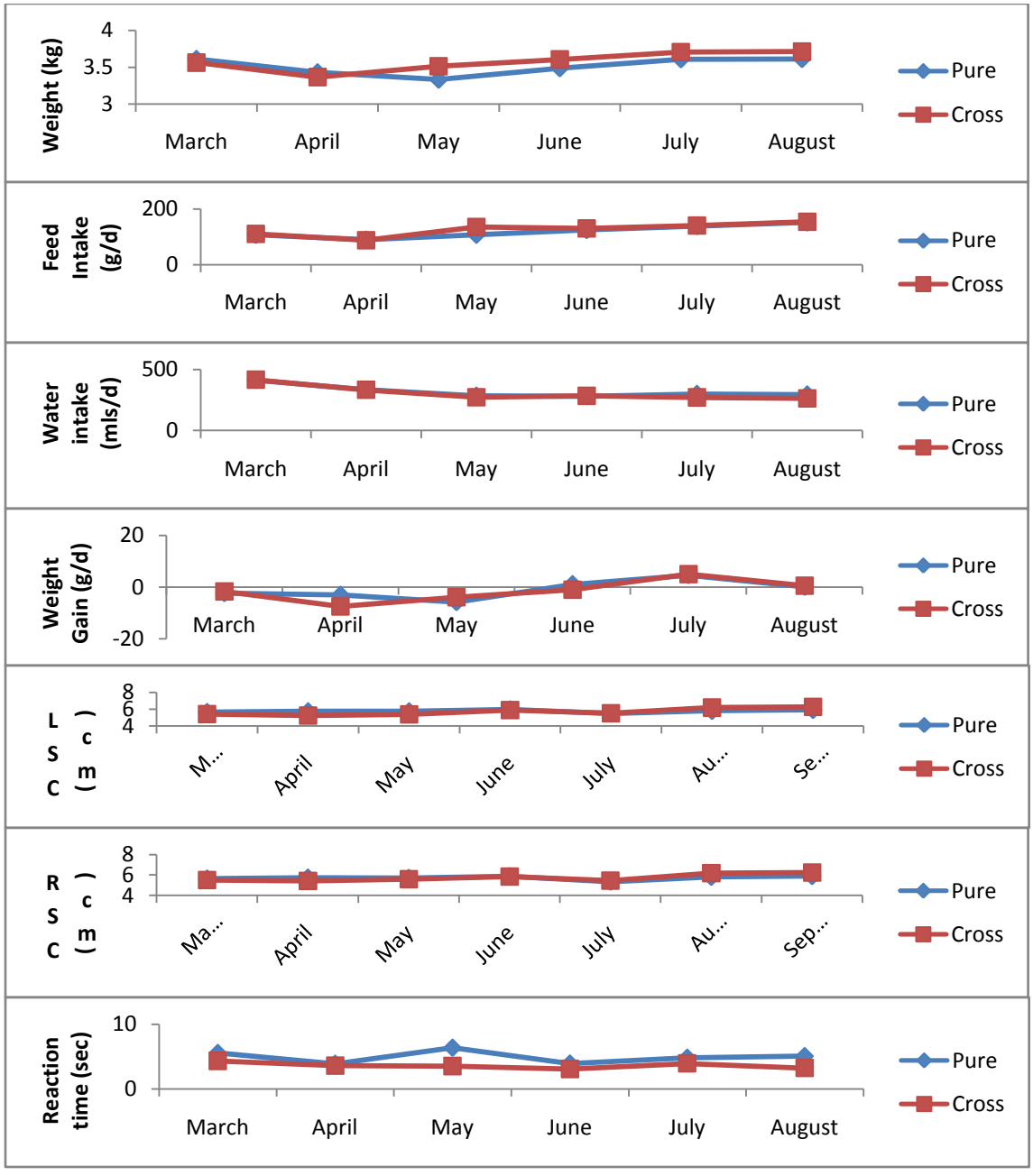


Figure 3: Effect of interaction between Breed and Month on Performance of Rabbit Bucks

4.11 Effects of Vitamin C levels on Thermoregulatory parameters of Rabbit Bucks

Table 4.8 shows effect of vitamin C levels on thermoregulatory parameters of rabbit bucks. There were no significant differences ($p>0.05$) on skin, ear, and scrotal temperature, heart and respiratory rate across vitamin C levels. Rectal temperature for bucks fed 100 mg vitamin C was significantly ($p<0.05$) higher than that of bucks fed other vitamin C levels.

4.12 Effect of Breed on Thermoregulatory parameters of Rabbit Bucks Fed Vitamin C Supplemented Diets

Table 4.9 shows the effects of breed on thermoregulatory parameters of rabbit bucks fed vitamin C supplemented diets. There was no significant differences ($p>0.05$) on skin, ear, scrotal and rectal temperature as well as respiratory and heart rate.

4.13 Effect of Season on Thermoregulatory parameters of Rabbit Bucks Fed Vitamin C Supplemented Diets

Table 4.10 shows the effect of season on thermoregulatory parameters of rabbit bucks fed vitamin C supplemented diets. Skin temperature in the cool wet was significantly ($p<0.05$) higher than in the hot dry season. Ear, rectal and scrotal temperature in the hot dry was significantly ($p<0.01$) higher than in the cool wet season. Heart and respiratory rates in the hot dry were also significantly ($p<0.01$) higher than in the cool wet season.

Table 4.8: Effect of Vitamin C levels on Thermoregulatory Parameters of Rabbit Bucks

Parameters	Vitamin C (mg/kg) Feed				p-v
	100	200	300	400	
Skin Temperature(^{o}C)	36.28±0.11	36.56±0.11	36.54±0.10	36.70±0.11	0.1
Ear Temperature(^{o}C)	35.30±0.13	35.44±0.14	35.58±0.13	35.47±0.14	0.5
Scrotal Temperature(^{o}C)	36.44±0.20	36.57±0.21	36.89±0.20	36.51±0.21	0.6
Rectal Temperature(^{o}C)	37.95±0.11^{a}	37.87±0.11^{b}	37.70±0.11^{c}	37.38±0.11^{d}	0.0030
Heart rate (b.p.m)	123.77±1.72	119.16±1.81	121.87±1.67	123.18±1.77	0.3
Respiratory rate(c.p.m)	120.81±2.04	119.99±2.15	119.97±1.98	125.97±2.11	0.15

Means along row with different superscript letters are significantly different ($p<0.05$)

Table 4.9: Effect of Breed on Thermoregulatory Parameters of Rabbit Bucks Fed Vitamin C Supplemented Diets

Parameters	Pure	Cross	p-v
Skin temperature (^{o}C)	36.46±0.86	36.57±0.09	0.3
Ear temperature(^{o}C)	35.39±0.07	35.50±0.12	0.4
Scrotal temperature (^{o}C)	36.68±0.11	36.57±0.17	0.6
Rectal temperature (^{o}C)	37.69±0.06	37.75±37.74	0.6
Heart rate (b.p.m)	122.03±0.94	122.02±1.45	0.1
Respiratory rate (c.p.m)	121.51±1.24	121.72±1.73	0.9

Table 4.10: Effect of Season on Thermoregulatory Parameters of Rabbit Bucks Fed Vitamin C Supplemented Diets

Parameter.	Hot -Dry	Cool -Wet	Probability
Skin temperature(^{o}C)	36.38±0.07^{b}	36.66±0.08^{a}	0.01
Ear temperature(^{o}C)	36.08±0.08^{a}	34.75±0.09^{b}	.0001
Rectal temperature(^{o}C)	38.11±0.07^{a}	37.29±0.08^{b}	.0001
Scrotal temperature(^{o}C)	36.94±0.14^{a}	36.27±0.15^{b}	0.001
Heart rate (b.p.m)	125.51±1.17^{a}	118.14±1.24^{b}	.0001
Respiratory rate (c.p.m)	127.58±1.37^{a}	115.01±1.46^{b}	.0001

Means along rows with different superscript letters are significantly different ($p<0.01$)

4.14 Effect of Month on Thermoregulatory Parameters of Rabbit Bucks Fed vitamin C Supplemented Diets

Table 4.11 shows effect of month on thermoregulatory parameters of rabbit bucks fed vitamin C supplemented diets. Skin temperature of bucks decreased from the months of March to June, and significantly ($p<0.01$) increased from the months of July, August to September. Ear temperature of bucks increased significantly ($p<0.01$) in the months of March and April, and decreased relatively from the months of May to August, and followed increase in September. Scrotal temperature of bucks fluctuate as the month of the year changes, although, there was significant ($p<0.01$) uniformly decrease from the months of July to August. Rectal temperature of bucks increases significantly ($p<0.01$) from the months of March to May, and decreased from the month of June to September. Heart and respiratory rates of bucks changed with month of year increasing in March and April and decreasing in May and June, then increasing again from the July to August.

4.15 Effect of Interaction between Vitamin C levels and Breed on Thermoregulatory Parameters of Rabbit Bucks

Table 4.12 shows the effect of interaction between vitamin C levels and breed on thermoregulatory parameters of rabbit bucks. There were no interaction between vitamin C levels and breed on skin, ear, and scrotal temperature as well as heart and respiratory rate ($p>0.05$). There was interaction between vitamin C level and breed on rectal temperature ($p<0.05$). Rectal temperature was high in crossbred bucks fed 300mg vitamin C.

Table 4.11: Effect of Month on Thermoregulatory Parameters of Rabbit Bucks Fed Vitamin C Supplemented Diets

Parameters	March	April	May	June	July	August	September	p-v
Skin Temp (^{o}C)	36.73±0.12^{d}	36.58±0.10^{e}	35.72±0.13^{f}	35.73±0.13^{f}	36.80±0.13^{c}	37.02±0.13^{b}	37.45±0.19^{a}	.0001
Ear Temp (^{o}C)	36.33±0.15^{a}	36.24±0.12^{b}	35.57±0.15^{c}	34.73±0.16^{d}	34.61±0.16^{d}	34.44±0.16^{d}	35.68±0.23^{c}	.0001
Scrotal Temp(^{o}C)	37.81±0.25^{a}	36.26±0.21^{f}	37.05±0.26^{b}	36.39±0.27^{c}	36.34±0.27^{d}	36.09±0.27^{g}	36.28±0.38^{e}	.0001
Rectal temp (^{o}C)	38.88± 0.12^{a}	37.75±0.10^{c}	37.84±0.13^{b}	37.26±0.14^{e}	37.47±0.14^{d}	37.21±0.13^{f}	37.17±0.19^{g}	.0001
Heart Rate (b.p.m)	136.182±1.85^{a}	129.60±1.55^{b}	107.97±1.91^{f}	102.59±2.01^{g}	126.01±2.02^{d}	120.61±1.98^{e}	128.34±2.81^{c}	.0001
Respiratory Rate(c.p.m)	148.78±1.82^{a}	132.55±1.52^{b}	97.54±1.88^{f}	95.25±1.98^{g}	123.25±1.98^{d}	123.43±1.96^{c}	120.92±2.76^{e}	.0001

Means along rows with different superscript letters are different ($p<0.01$)

Table 4.12: Effect of Interaction between Vitamin C levels and Breed on Thermoregulatory Parameters of Rabbit Bucks

Parameter	100		200		300		400		
	Pure	Cross	Pure	Cross	Pure	Cross	Pure	Cross	p-v
Skin Temp(^{o}C)	36.41±0.11	36.15±0.18	36.36±0.11	36.79±0.19	36.51±0.11	36.57±17	36.62±0.14	36.78±0.17	0.18
Ear Temp (^{o}C)	35.26±0.14	35.33±0.23	35.49±0.14	35.39±0.24	35.35±0.14	35.80±0.21	35.49±0.17	35.45±0.21	0.45
Scro Temp (^{o}C)	36.67±0.21	36.21±0.34	36.85±0.21	36.28±0.37	36.71±0.22	37.07±0.33	36.38±0.26	36.63±0.33	0.25
Rect Temp (^{o}C)	37.94±0.11^{d}	37.97±0.18^{c}	37.75±0.11^{e}	37.99±0.20^{b}	37.38±0.12^{h}	38.03±0.18^{a}	37.68±0.14^{g}	37.07±0.18^{f}	0.0007
Heart rate(b.p.m)	123.26±1.81	124.28±2.92	119.96±1.80	118.36±3.15	122.17±1.84	121.57±2.79	123.08±2.19	123.29±2.80	0.96
Respi rate (c.p.m)	121.77±2.2	119.84±3.5	118.93±2.13	121.05±3.74	122.11±2.18	117.82±3.31	124.09±2.60	127.86±3.31	0.49

Means along row with different superscript letters are significantly different ($p<0.01$)

4.16 Effect of Interaction between Vitamin C levels and Season on Thermoregulatory Parameters of Rabbit Bucks

Table 4.13 shows the effect of interaction between vitamin C levels and season on thermoregulatory parameters of rabbit bucks. There were no interactions between vitamin C levels and season for skin, ear, scrotal, and rectal temperature as well as heart rate ($p>0.05$). There was interaction between vitamin C levels and season for respiratory rate ($p<0.05$). Respiratory rate of bucks was significantly ($p<0.05$) higher for bucks fed 100 mg/kg vitamin C level during the hot dry season.

4.17 Effect of Interaction between Vitamin C levels and Month on Thermoregulatory Parameters

Figure 4 shows the effect of interaction between vitamin C levels and month on thermoregulatory parameters of rabbit bucks. There was interaction between vitamin C levels and month for skin temperature ($p<0.05$). Skin temperature was decreases from the months of March to June, and increases from July to September in all vitamin C levels. There was interaction between vitamin C levels and month for ear temperature ($p<0.01$). Ear temperature was relatively high in the month of April for bucks fed 100 mg vitamin C. There was interaction between vitamin C levels and month for heart rate ($p<0.01$). Heart rate increased in the month of March in bucks fed 100 mg/kg vitamin C. There was interaction between vitamin C levels and month on respiratory rate ($p<0.01$). Respiratory rate increases from the month of March to April and decreased from July to September at all vitamin C levels. Rectal and scrotal temperature was not significant.

Table 4.13: Effect of Interaction between Vitamin C levels and Season on Thermoregulatory Parameters of Rabbit Bucks

	100		200		300		400		
Parameters	Hot -Dry	Cool -Wet	Hot- Dry	Cool -Wet	Hot -Dry	Cool- Wet	Hot- Dry	Cool -Wet	p- v
Skin Temp (^{o}C)	36.18±0.13	36.53±01	36.46±0.13	36.48±0.14	36.38±0.13	36.68±0.13	36.44±0.15	36.96±0.1	0.3
Ear Temp (^{o}C)	35.97±0.15	34.55±0.16	35.94±0.15	34.91±0.16	36.03±0.15	34.92±0.15	36.32±0.17	34.54±0.17	0.08
Scrotal Temp (^{o}C)	36.72±0.25	36.36±0.26	37.29±0.25	36.04±0.27	37.12± 0.25	36.51±0.25	36.67± 0.28	36.3± 0.30	0.3
Rectal Temp (^{o}C)	38.38±0.13	37.49±0.13	38.27±0.13	37.27±0.14	37.98±0.13	37.16±0.13	37.97±0.14	36.88±0.15	0.8
Heart Rate. (b.p.m)	127.91±2.11	118.88±2.18	122.32±2.10	116.39±2.25	126.38±2.12	117.45±2.15	124.83±2.34	121.31±2.5	0.6
Resp Rate.(c.p.m)	131.07±2.45^{a}	110.74±2.53^{f}	125.73±2.44^{c}	112.19±2.62^{g}	125.98±2.46^{c}	115.47±2.50^{e}	127.43±2.72^{b}	123.44±2.85^{d}	0.02

Means along row with different superscript letters are significantly different ($p<0.02$)

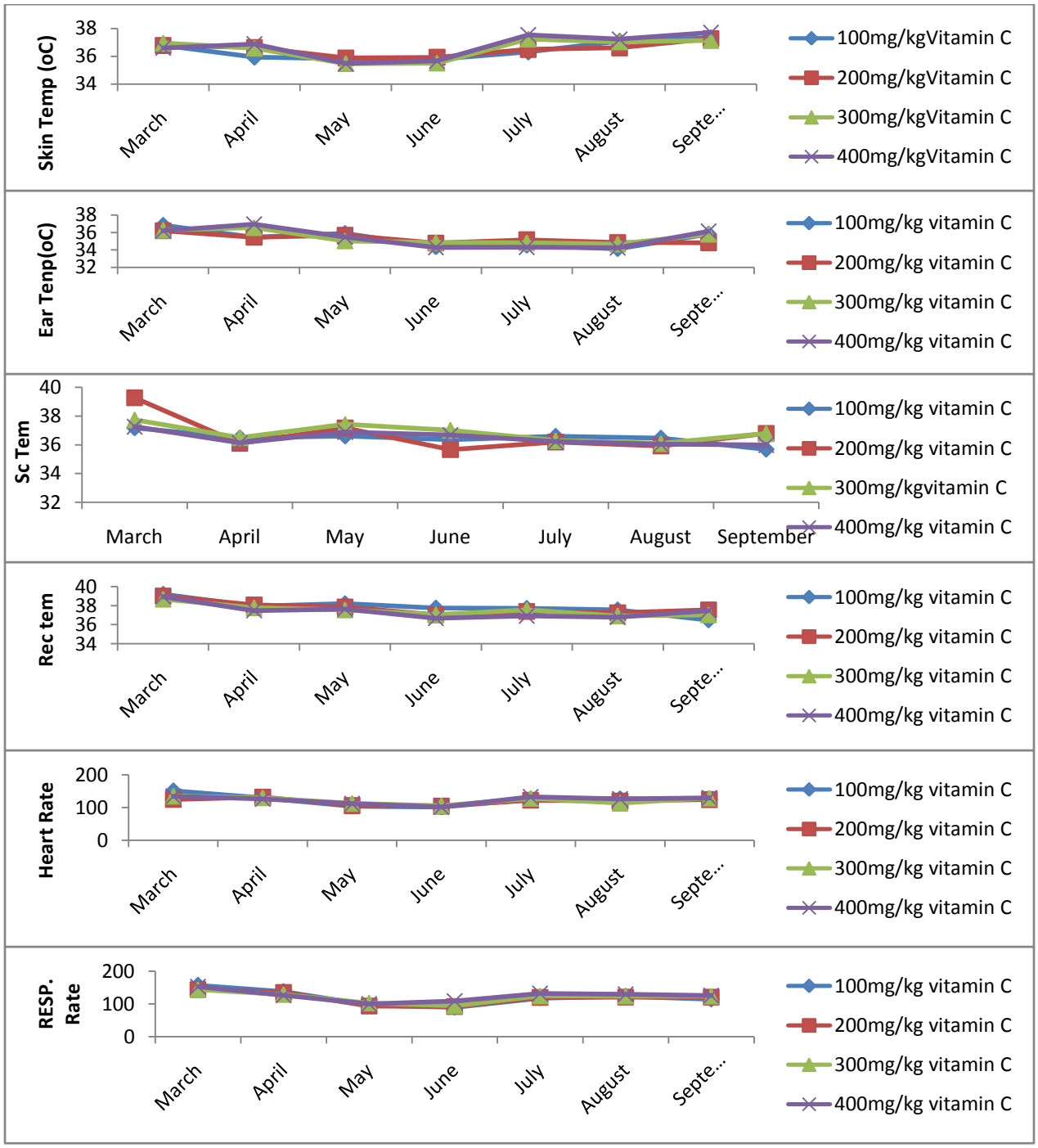


Figure 4: Effect of Interaction between Vitamin C levels and Month on Thermoregulatory Parameters of Rabbit Bucks

4.18 Effect of Interaction between Breed and Season on thermoregulatory parameters of Rabbit Bucks Fed Vitamin C supplemented Diets

Table 4.14 shows effect of interaction between breed and season on thermoregulatory parameters of rabbit bucks. There were no interactions between breed and season for skin, ear and scrotal temperature ($p>0.05$). There was interactions between breed and season for rectal temperature ($p<0.05$). Rectal temperature was high at purebred during hot dry than cool wet season. Heart and respiratory rate were not significantly ($p>0.05$) different on interaction between breed and season.

4.19 Effect of Interaction between Breed and Month on Thermoregulatory Parameters of Rabbit Bucks Fed Vitamin C supplemented Diets

Figure 5 shows the effect of interaction between breed and month for thermoregulatory parameters of rabbit bucks. There were no interactions between breed and month for skin, ear and scrotal temperature heart and respiratory rates ($p>0.05$). There was interaction between breed and month for rectal temperature ($p<0.05$). Rectal temperature increased in the month of March at pure and crossbred.

4.20 Effects of Vitamin C levels on Semen characteristics of Rabbit Bucks

Table 4.15 shows effect of vitamin C levels on semen characteristics of rabbit bucks. There was no significant ($p>0.05$) difference in semen motility, concentration, pH, semen volume and dead sperm across vitamin C levels. Live sperm of bucks fed 400mg vitamin C level was significantly ($p<0.05$) higher than in other vitamin C levels.

Table 4.14: Effect of Interaction between Breed and Season on Thermoregulatory Parameters of Rabbit bucks Fed Vitamin C Supplemented Diets

Parameters	Pure		Cross		p-v
	Hot-Dry	Cool-Wet	Hot-Dry	Cool-Wet	
Skin Temperature(^{o}C)	36.38± 0.07	36.66± 0.08	36.46± 0.06	36.57± 0.09	0.6
Ear Temperature(^{o}C)	36.08± 0.08	35.75±0.08	35.39±0.07	35.50± 0.11	0.8
Scrotal Temperature(^{o}C)	36.94± 0.14	36.27± 0.15	36.68± 0.11	36.57± 0.17	0.96
Rectal Temperature(^{o}C)	38.11± 0.07^{a}	37.29± 0.08^{c}	37.69± 0.06^{d}	37.75± 0.09^{b}	0.003
Heart Rate (b.p.m)	125.51± 1.17	118.14± 1.24	122.0.25± 0.94	122.02± 1.45	0.6
Respiratory Rate (c.p.m)	127.58± 1.37	115.01± 1.46	121.51± 1.12	121.72± 1.73	0.92

Means along row with different superscript letters are significantly different ($p<0.05$)

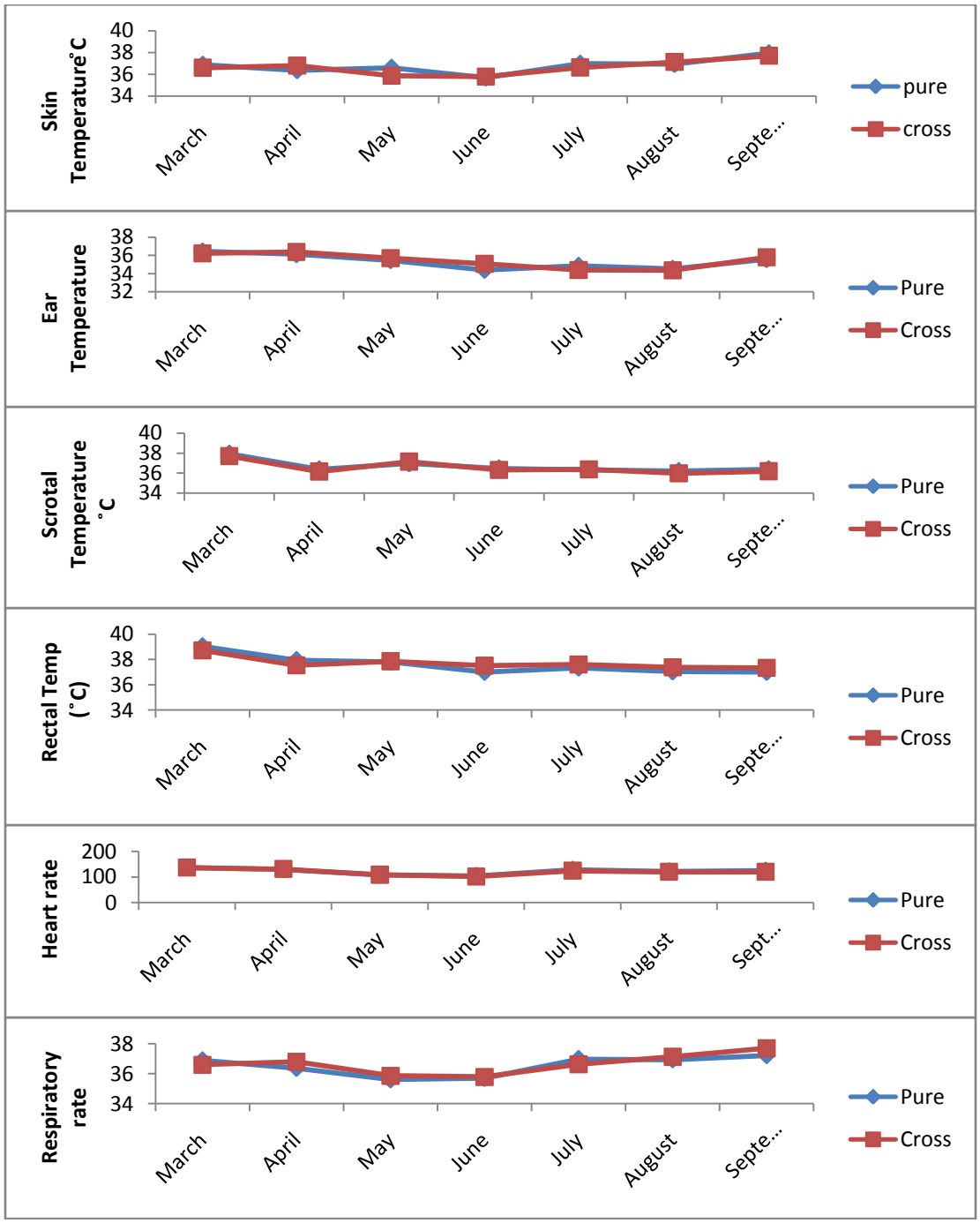


Figure 5: Effect of Interaction between Breed and Month on Thermoregulatory Parameters of Rabbit Bucks

Table 4.15: Effect of Vitamin C levels on Semen Characteristics of rabbit Bucks

	Vitamin C levels (mg/kg feed)				
Parameters	100	200	300	400	p-v
Sperm Motility (%)	63.19±2.86	66.90±2.88	71.07± 3.09	73.58±3.35	0.08
Concentration($\times 10^6$)	80.13±11.79	100.15±11.87	114.16±12.74	118.12±13.80	0.13
Semen Volume(ml)	1.29±0.18	0.91±0.18	0.74±0.24	1.17±0.21	0.16
Semen pH	6.81±0.18	7.13±0.18	6.85±0.20	6.65±0.21	0.4
Color	Milky	Milky	Milky	Milky	0.4
Live Sperm	84.79±1.46^{c}	84.05±1.41^{d}	85.69±1.78^{b}	89.63±1.50^{a}	0.05
Dead Sperm	15.05±1.47	15.95±1.43	14.27±1.79	10.37±1.60	0.06

Means along row with different superscript letters are significantly different ($p \leq 0.05$)

4.21 Effects of Breed on Semen Characteristics of Rabbit Bucks Fed Vitamin C Supplemented Diets

Table 4.16 shows effect of breed on semen characteristics of rabbit buck fed diets supplemented with vitamin C. There was no significant ($p>0.05$) differences in semen motility, concentration, semen volume, pH and color between breed. Live sperm in crossbred was significantly ($p<0.05$) higher than in purebred, while dead sperm in purebred was significantly ($p<0.05$) higher than in crossbred.

4.22 Effects of Season on Semen Characteristics of Rabbit Bucks Fed Vitamin C Supplemented Diets

Table 4.17 shows effect of season on semen characteristics of rabbit bucks fed diets supplemented with vitamin C. There was no significant ($p>0.05$) difference in sperm motility, concentration, pH and colour between seasons. Semen volume was significantly ($p<0.05$) higher at hot dry than cool wet season. Live sperm was significantly ($p<0.01$) higher at cool wet than hot dry season, while dead sperm was significantly ($p<0.01$) higher at hot dry than cool wet season.

4.23 Effect of Month on Semen Characteristics of Rabbit Bucks Fed Vitamin C Supplemented Diets

Table 4.18 shows the effect of month on semen characteristics of rabbit bucks fed diets supplemented with vitamin C. Semen volume was significantly ($p<0.05$) affected by the month of the year. Semen volume increased in the month of April. Sperm motility was significantly ($p<0.05$) increased in the month of June. There was no significant differences in sperm concentration ($p>0.05$) across months of the year. There was no significant differences on semen pH ($p>0.05$) across months. Semen colour was predominantly milky throughout the months of the year. Live sperm decreased from the month of March to May, and increased significantly

($p<0.01$) from the month of June to August. Dead sperm significantly ($p<0.01$) increased in the month of April.

4.24 Effect of Interaction between Vitamin C levels and Breed on Semen Characteristics of Rabbit Bucks

Table 4.19 shows effect of interaction between vitamin C levels and breed on semen characteristics of rabbit bucks. There was no interactions between vitamin C levels and breed in sperm motility, sperm concentration, semen volume, pH, semen color, Live and dead sperm ($p>0.05$).

4.25 Effect of Interaction between Vitamin C levels and Season on Semen Characteristics of Rabbit bucks

Table 4.20 shows the effect of interaction between vitamin C levels and season on semen characteristics of rabbit bucks. There was no interaction between vitamin C levels and season in sperm motility, concentration, semen volume, semen pH, live and dead sperm ($p>0.05$).There was interaction between vitamin C levels and season in semen colour ($p<0.05$). Semen colour was higher in bucks fed 400 mg vitamin C at hot dry season.

4.26 Effect of Interaction between Vitamin C levels and Month on Semen Characteristics of Rabbit Bucks

Figure 6 shows effect of interaction between vitamin C levels and month on semen characteristics of rabbit bucks. There were no interactions between vitamin C levels and month in sperm motility, concentration, volume, pH, colour, live and dead sperm.

4.27 Effect of Interaction between Season and Breed on Semen Characteristics of Rabbit Bucks

Table 4.21 shows effect of interaction between season and breed on semen characteristic of rabbit bucks. There was no interactions between season and breed in semen motility, concentration, semen volume, pH, colour, live and dead sperm ($p>0.05$).

Table 4.16: Effect of Breed on Semen Characteristics of Bucks Fed Diets Supplemented with Vitamin C

Parameters	Pure	Cross	p-v
Semen motility(%)	69.98±1.78	65.59±3.00	0.2
Semen volume(ml)	1.08±0.11	0.87±0.19	0.3
Semen concentration($\times 10^6$)	109.86±7.28	86.58±12.23	0.1
Semen pH	6.77±0.11	7.18±0.19	0.07
Semen color	1.40±0.06	1.20±0.10	0.09
Live Sperm	83.87 ± 0.75^{b}	86.98 ± 1.2^{a}	0.03
Dead Sperm	16.2 ± 0.76^{a}	12.85 ± 1.2^{b}	0.02

Means along rows with different superscript letters are significantly different ($p<0.05$)

Table 4.17: Effect of Season on Semen Characteristics of Bucks Fed Diets Supplemented with Vitamin C

Parameters	Hot -Dry	Cool -Wet	p-v
Semen motility(%)	65.88±2.19	71.49±2.12	0.07
Semen concentration($\times 10^6$)	102.48±9.05	103.80±8.74	0.92
Semen volume(ml)	1.317 ± 0.14^a	0.73 ± 0.13^b	0.003
Semen pH	6.76±0.14	6.96±0.13	0.3
Color	1.33±0.07	1.37±0.07	0.7
Live Sperm	80.71 ± 1.0^b	90.14 ± 0.9^a	.0001
Dead Sperm	19.13 ± 1.0^a	9.89 ± 0.94^b	.0001

Means along rows with different superscript letters are significantly different ($p<0.05$)

Table 4.18: Effect of Month on Semen Characteristics of Rabbit Bucks Fed Diets Supplemented with Vitamin C

Parameters	March	April	May	June	July	August	p-v
Semen Volume(ml)	1.38±0.32^{b}	1.43±0.24^{a}	1.32± 0.21^{c}	0.95± 0.19^{d}	0.41±0.25^{e}	0.69±0.32^{e}	0.02
Sperm Motility (%)	67.45±5.00^{d}	60.01±3.74^{f}	70.96± 3.32^{b}	75.16± 2.92^{a}	70.05±3.88^{c}	61.97±5.00^{e}	0.02
Sperm Concentration ($\times 10^{6}$)	75.72± 20.87	129.48± 15.63	62±13.85	102.78±12.17	100.26±16.20	98.17±20.87	0.4
Semen pH	7.23± 0.32	6.45±0.24	6.65±0.21	6.89± 0.19	7.04±0.25	6.93±0.32	0.3
Semen Colour	1.34± 0.16^{d}	1.63±0.12^{a}	1.11±0.11^{f}	1.31±0.10^{e}	1.50±0.13^{b}	1.36±0.16^{c}	0.05
Live Sperm		75.96± 1.47^{e}	84.78±1.35^{d}	89.29±1.24^{c}	90.19±1.72^{b}	92.55±2.08^{a}	.0001
Dead Sperm		24.18±1.48^{a}	14.79±1.36^{b}	10.71±1.26^{c}	9.94±1.74^{d}	7.45±2.10^{e}	.0001

Means along rows with different superscript letters are significantly different ($p<0.05$)

Table 4.19: Effects of Interaction between Vitamin C levels and Breed on Semen Characteristics of Rabbit Bucks

Parameters	100		200		300		400		p-v
	Pure	Cross	Pure	Cross	Pure	Cross	Pure	Cross	
Motility	63.14±3.39	61.11±5.44	70.27±3.50	60.7±5.05	72.55±3.46	65.91±7.15	74.0±3.90	74.67±6.12	0.7
Conc($\times 10^6$)	82.6±13.8	70.3±22.2	108.±14.3	89.8±20.6	120.±14.1	92.2±29.2	129.±15.9	94.0±24.9	0.9
Volume(ml)	1.51±0.22	0.79±0.35	1.02±0.22	0.71±0.32	0.64±0.22	1.02±0.46	1.14±0.25	0.93±0.4	0.4
Semen pH	6.61±0.21	7.32±0.34	7.08±0.22	7.25±0.32	6.79±0.22	7.14±0.45	6.50±0.24	7.00±0.38	0.8
Semen Color	1.33±0.11	1.12±0.18	1.40±0.12	1.27±0.17	1.34±0.11	1.10±0.24	1.52±0.13	1.33±0.02	0.98
Live Sperm	80.85±1.55	88.72±2.48	84.90±1.66	83.19±2.30	85.02±1.6	86.36±3.17	87.32±1.80	91.74±2.63	0.11
Dead Sperm	19.37±1.56	10.72±2.50	15.1±1.67	16.81±2.31	14.91±1.62	13.63±3.19	12.68±1.82	8.06±2.6	0.07

Table 4.20: Effect of Interaction between Vitamin C levels and Season on Semen Characteristics of Rabbit Bucks

Parameters	100		200		300		400		p-v
	Hot -Dry	Cool-Wet	Hot -Dry	Cool-Wet	Hot-Dry	Cool-Wet	Hot -Dry	Cool-Wet	
Motility	56.38±3.86	70.00±4.22	68.46±3.76	65.34±4.36	67.78±4.52	74.36±4.22	70.90±5.25	76.25±4.15	0.24
Concentration	68.95±15.92	91.32±17.40	114.92±15.51	85.38±17.20	111.52±18.64	116.81±17.40	114.55±21.66	121.69±17.12	0.5
Volume	1.60±0.24	0.97±0.27	1.05±0.24	0.76±0.28	1.04±0.29	0.43±0.27	1.57±0.33	0.77±0.26	0.81
Semen pH	6.81±0.24	6.81±0.27	7.19±0.24	7.07±0.28	6.63±0.29	7.06±0.27	6.40±0.33	6.91±0.26	0.6
Semen Color	1.41 ± 0.13^{b}	1.07 ± 0.14^{c}	1.26 ± 0.12^{bc}	1.49 ± 0.14^{b}	1.08 ± 0.15^{c}	1.48 ± 0.14^{b}	1.56 ± 0.17^{a}	1.41 ± 0.14^{b}	0.04
Live Sperm	75.81±1.67	90.31±1.67	79.69±1.7	89.32±1.8	81.32±1.9	88.72±1.8	85.31±2.4	90.44±1.6	0.06
Dead Sperm	24.19±1.7	9.69±1.7	20.31±1.7	10.59±1.8	18.32±1.9	11.48±1.8	14.69±2.4	9.6±1.64	0.06

Means along row with different superscript letters are significantly different ($p<0.05$)

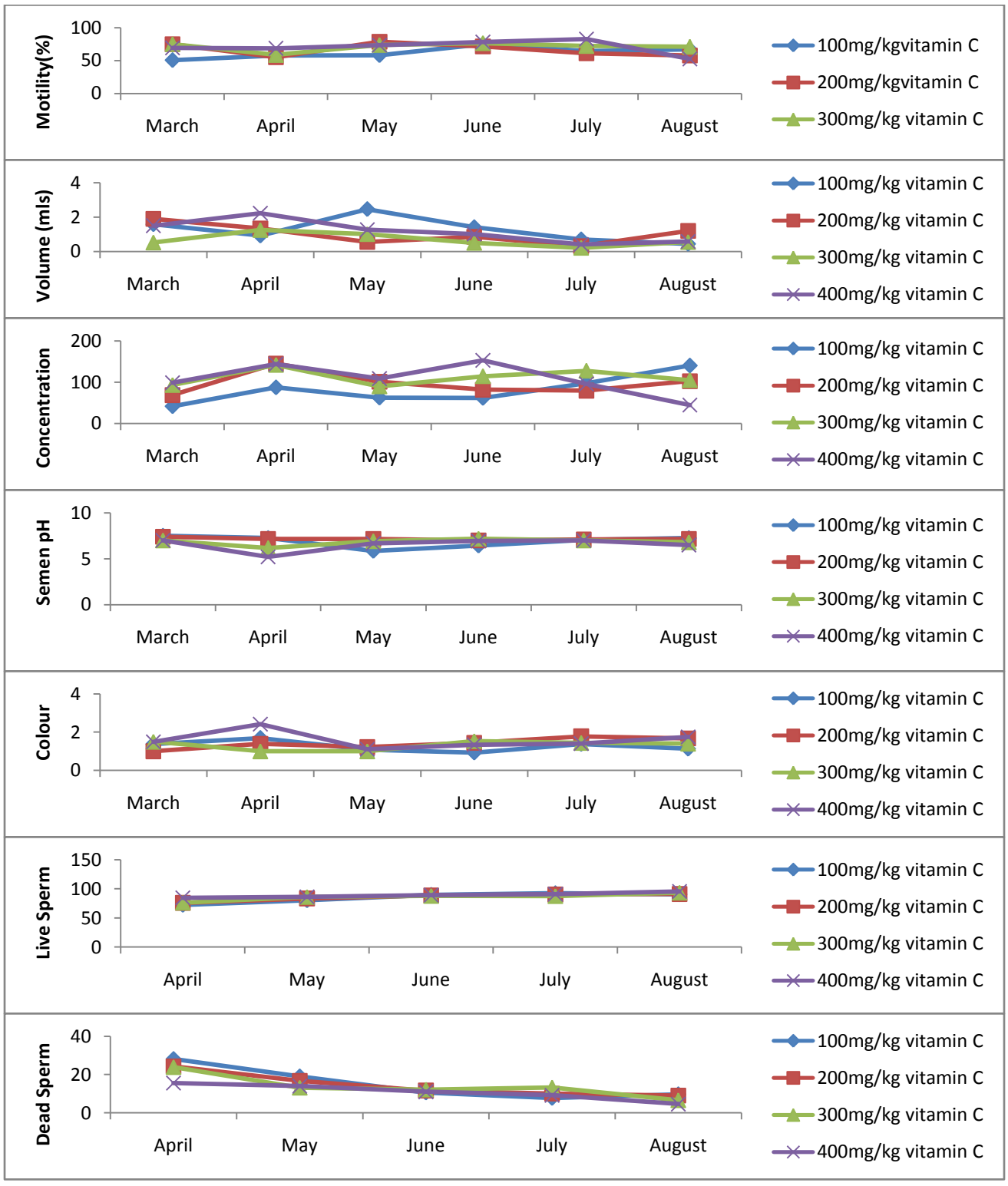


Figure 6: Effect of interaction between Vitamin C levels and Month on Semen Characteristics of Rabbit Bucks

Table 4. 21: Effect of Interaction between Season and Breed on Semen Characteristics of Rabbit Bucks

Parameters	Pure		Cross		p-v
	Hot- Dry	Cool- Wet	Hot- Dry	Cool -Wet	
Sperm Motility (%)	66.34±3.13	77.27±3.29	66.58±5.31	73.90±5.23	0.6
Semen Concentration($\times 10^6$)	101.69±10.5	102.84±10.98	90.03±17.75	79.38±79.4	0.7
Semen Volume(ml)	1.11±0.11	0.50±0.11	0.78±0.19	0.54±0.19	0.2
Semen pH	10.19±1.73	12.78±1.81	7.37±2.9	11.73±2.88	0.7
Semen color	milky	Milky	milky	milky	0.4
Live Sperm	78.48±1.1	89.25±1.0	82.93±1.7	91.03±1.6	0.3
Dead Sperm	21.53±1.11	10.82±1.0	16.73±1.8	8.97±1.6	0.3

4.28 Effect of Interaction between Breed and Month on Semen Characteristics of Rabbit Bucks

Figure 7 shows effect of interaction between breed and month on semen characteristics of rabbit bucks. There were no interactions between breed and month in motility, concentration, volume, colour, pH, live and dead sperm.

4.29 Effect of Vitamin C levels on Sperm Morphology of Rabbit Bucks

Table 4.22 shows the effect of vitamin C levels on sperm morphology of rabbit bucks. There were no significant ($p>0.05$) differences for normal and abnormal sperm, tailless head, rudimentary tail, curved mid piece, mid piece droplet, coiled tail, narrow head, round cell, dag defect, proximal droplet round double tail, ruffled acrosome, trans locating cytoplasmic droplets, tail opening droplet trans location, double head neck and flagellum across vitamin C levels. Stump tail was significantly ($p<0.05$) higher in bucks fed 100 mg/kg vitamin C. Bent mid piece was significantly ($p<0.05$) higher in bucks on 300 mg vitamin C than other vitamin C levels. Double head single neck and flagellum was significantly ($p<0.05$) higher in bucks fed 300mg vitamin C. than bucks fed other vitamin C levels.

4.30 Effect of Breed on Sperm Morphology of Rabbit Bucks Fed diets Supplemented with Vitamin C

Table 4.23 shows the effect of breed on sperm morphology of rabbit bucks fed diets supplemented with vitamin C. There was no significant ($p>0.05$) differences between breed in normal and abnormal sperm, tailless head, rudimentary tail, narrow head, stump tail, round double tail, ruffle acrosome, pyriform, bent tail, coiled tail, curved mid piece, dag defect, proximal cytoplasmic droplet, translocation cytoplasmic droplet, round cell, tail opening droplet translocation, double head neck and flagellum, double head single neck and flagellum, bent mid piece, mid piece droplet.

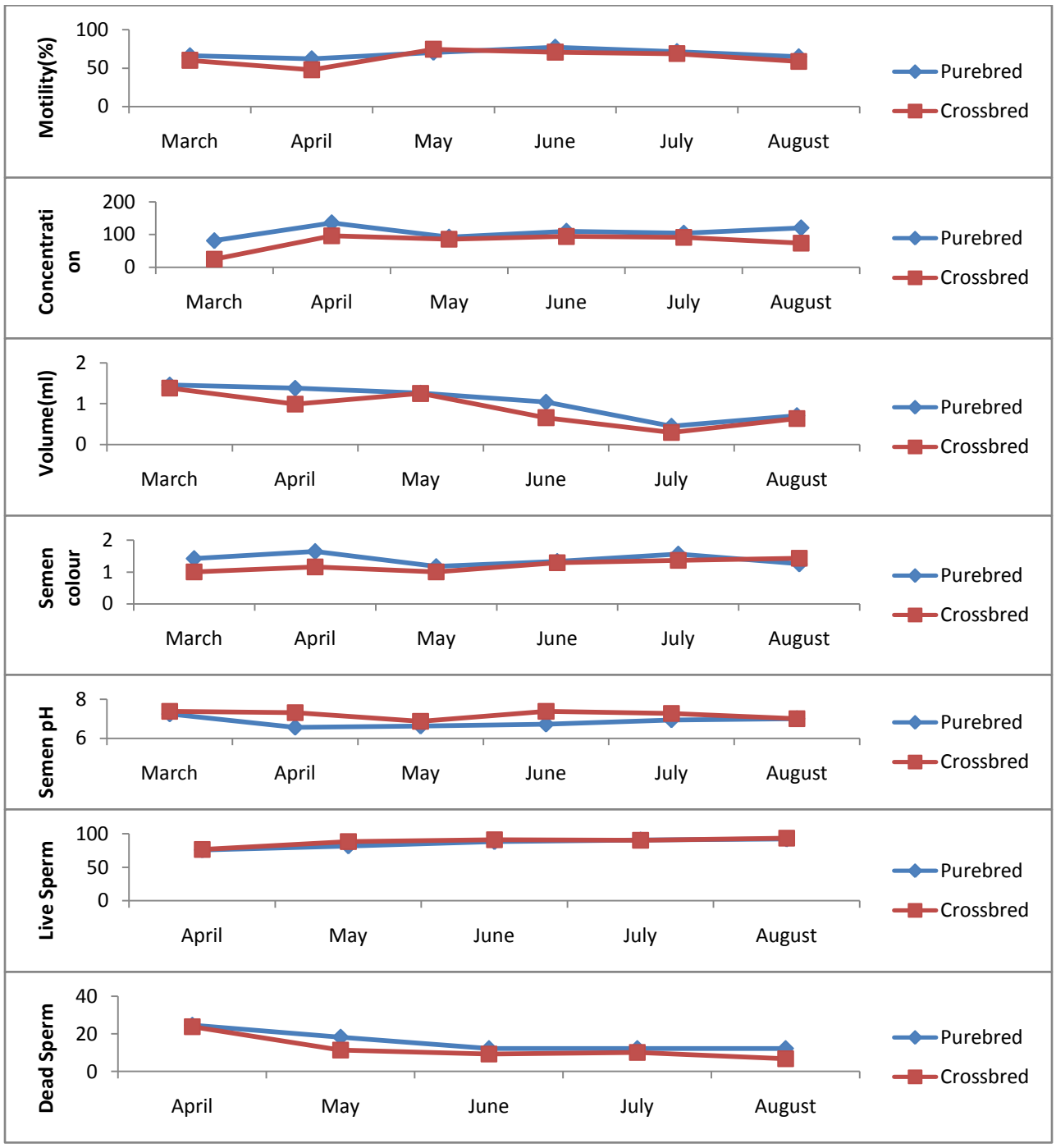


Figure 7: Effect of interaction between Breed and Month on Semen Characteristics of Rabbit Bucks

Table 4.22: Effect of Vitamin C levels on Sperm Morphology of Rabbit Bucks

Parameters	100	200	300	400	p-v
Normal sperm	67.45±2.38	67.26±2.28	58.31±2.89	66.02±2.63	0.3
Abnormal sperm	31.26±2.33	33.00±2.29	33.45±2.83	33.09±2.57	0.8
Primary Abnormalities:					
Tailless head	4.84±0.72	6.12±0.71	7.15±0.75	7.39±0.83	0.3
Rudimentary tail	2.01±0.33	1.89±0.34	2.89±0.35	2.37±0.38	0.5
Narrow head	3.49±0.45	2.73±0.46	3.30±0.5	3.36±0.52	0.8
Stump tail	1.66±0.28^{a}	1.42±0.26^{b}	0.92±0.33^{c}	0.38±0.30^{d}	0.01
Pyriforms	0.00±0.01	0.00±0.01	0.05±0.02	0.02±0.07	0.09
Ruffled acrosome	0.12±0.06	0.09±0.06	0.12±0.07	0.00±0.07	0.6
Round double tail	0.071±0.06	0.00±0.06	0.05±0.08	-0.00±0.07	0.8
Secondary Abnormalities:					
Bent tail	4.31±0.41	4.94±0.42	4.50±0.43	4.45±0.47	0.9
Coiled tail	2.87±0.36	3.17±0.37	2.93±0.38	2.12±0.42	0.2
Dag defect	0.15±0.08	0.05±0.09	0.08±0.09	0.23±0.10	0.6
Trans location cytoplasmic droplet	0.012±0.03	0.04±0.03	0.10±0.03	0.00±0.29	0.1
Proximal cytoplasmic droplet	0.00±0.025	0.03±0.02	0.06±0.03	0.07±0.03	0.2
Tail opening droplet translocation	0.02±0.06	0.05±0.06	0.07±0.08	0.08±0.07	0.9
Double head neck and flagellum	0.37±0.11	0.13±0.10	0.20±0.13	0.31±0.12	0.4
Curve mid piece	1.99±0.37	1.95±0.40	2.92±0.39	3.11±0.43	0.06
Round cell	0.22±0.09	0.106±0.10	0.16±0.10	0.05±0.11	0.7
Bent Mid piece	3.76±0.39^{d}	4.59±0.40^{c}	5.50±0.411^{a}	5.38±0.45^{b}	0.01
Mid piece droplet	5.68±0.44	4.79±0.44	5.39±0.46	5.43±0.50	0.5
Double head single neck and flagellum	0.24±1.62^{c}	0.092±1.55^{d}	8.85±1.96^{a}	1.04±1.78^{b}	0.002

Means along rows with different superscript letters are significantly different ($p<0.05$)

Table 4.23: Effect of Breed on Sperm Morphology of Rabbit Bucks Fed Diet Supplemented with Vitamin C

Parameters	Pure	Cross	p-v
Normal Sperm	64.82±1.35	64.70±2.17	0.96
Abnormal Sperm	32.64±1.32	32.76±2.12	0.96
Primary Abnormalities			
Tailless Head	6.46±0.44	5.78±0.70	0.4
Rudimentary Tail	2.30±0.20	2.19±0.39	0.9
Round Double Tail	0.04±0.04	0.03±0.13	0.9
Narrow Head	3.10±0.21	3.36±0.43	0.6
Stump Tail	1.10±0.16	1.09±0.25	0.9
Ruffled acrosome	0.12±.02	0.04±0.06	0.2
Pyriforms	0.09±0.01	0.03±0.01	0.3
Secondary Abnormalities			
Bent tail	4.41±0.24	4.87±0.39	0.24
Coiled tail	2.73±0.22	3.14±0.35	0.4
Round cell	0.15±0.06	0.09±0.09	0.6
Dag defect	0.13±0.06	0.086±0.08	0.6
Proximal cytoplasmic droplet	0.02±0.01	0.06±0.023	0.2
Translocation cytoplasmic droplet	0.01±0.15	0.06±0.02	0.08
Tail opening droplet translocation	0.101±0.04	0.0132±0.06	0.2
Double head neck and flagellum	0.17±0.06	0.34±0.96	0.1
Double head single neck. and flagellum	2.14±0.92	2.97±1.47	0.6
Curved mid piece	2.29±0.23	2.81±0.39	0.15
Mid piece droplet	5.30±0.27	5.49±0.42	0.6
Bent mid piece	4.79±0.24	4.66±0.39	0.92

4.31 Effect of Season on Sperm Morphology of Rabbit Bucks Fed Diets Supplemented with Vitamin C

Table 4.24 shows the effect of season on sperm morphology of rabbit bucks fed diets supplemented with vitamin C. There was no significant ($p>0.05$) differences between season for normal sperm, stump tail, narrow sperm head, round double tail, ruffle acrosome, pyriforms, bent tail, coiled tail, dag defect, proximal cytoplasmic droplet, translocation cytoplasmic droplet, tail opening droplet translocation, double head neck and flagellum, double head single neck and flagellum, mid piece droplet and bent mid piece. Abnormal sperm increased significantly ($p<0.05$) at hot dry than in cool wet season. Tailless head increased significantly ($p<0.05$) at hot dry than cool wet season. Rudimentary tail increased significantly ($p<0.05$) at hot dry than cool wet season. Curved mid piece increased significantly ($p<0.05$) at hot dry than cool wet season. Round cell increased significantly ($p<0.05$) at cool wet than hot dry season.

Table 4.24: Effect of Season on Sperm Morphology of Rabbit Bucks Fed Diets Supplemented with Vitamin C

Parameters	Hot-Dry	Cool -Wet	p-v
Normal Sperm	63.36±1.65	66.47±1.62	0.2
Abnormal Sperm	34.83±1.60[a]	30.67±1.58[b]	0.04
Primary Abnormalities			
Tailless Head	6.83±0.58[a]	5.37±0.59[b]	0.03
Rudimentary Tail	2.94±0.27[a]	1.56±0.28[b]	0.0004
Stump Tail	1.29±0.19[a]	0.89±0.19	0.1
Narrow Head	3.61±0.36	2.85±0.36	0.3
Round Double Tail	0.00±0.04	0.07±0.04	0.2
Ruffled acrosome	0.10±0.04	0.10±0.04	0.98
Pyriforms	-0.00±0.010	0.02±0.00	0.2
Secondary Abnormalities			
Bent Tail	4.72±0.32	4.56±0.33	0.43
Coiled Tail	3.43±0.29	2.440±0.29	0.08
Dag Defect	0.06±0.07	0.16±0.07	0.7
Proximal Cytoplasmic Droplet	0.01±0.02	0.05±0.02	0.1
Translocation Cytoplasmic Droplets	0.023±0.02	0.02±0.02	0.96
Tail Opening Droplet Translocation	0.03±0.04	0.11±0.04	0.21
Double Head Neck and Flagellum	0.19±0.07	0.26±0.07	0.5
Double Head Single Neck and Flagellum	1.37±1.12	3.02±1.10	0.3
Curved Mid piece	2.95±0.30[a]	2.15±0.306[b]	0.03
Mid piece Droplet	5.35±0.35	5.44±0.36	0.7
Round Cell	0.013±0.08[b]	0.22±0.08[a]	0.02
Bent Mid piece	4.80±0.32	4.64±0.32	0.7

Means along rows with different superscript letters are significantly different ($p<0.05$)

4.32 Effect of Month on Sperm Morphology of Rabbit Bucks Fed Diets Supplemented with Vitamin C

Table 4.25 shows the effect of month on sperm morphology of rabbit bucks fed diets supplemented with vitamin C. There were no significant effect on normal and abnormal sperm, ruffle acrosomes, pyriform, round double tail, coiled tails, bent tail, dag defect dag, translocation cytoplasmic droplets, mid piece droplet, tail opening droplet translocation, double head single neck and flagellum, bent mid piece, curved mid piece and round cell across month.

Tailless head increased significantly ($p<0.05$) at the month of April and decreased at August. Rudimentary tail increased significantly ($p<0.05$) at the month of May and April and decreased at August. Stump tail increased significantly ($p<0.01$) at May and decreased at August. Narrow head increased significantly ($p<0.01$) at the month of August and decreased at July. Proximal Cytoplasmic droplet increased significantly ($p<0.01$) at the month of July followed by August and decreased at April to June. Double head neck and flagellum was significantly ($p\leq0.05$) increased at month of July and decreased at April.

4.33 Effect of Interaction between Vitamin C levels and Breed on Sperm Morphology of Rabbit Bucks

Table 4.26 shows the effect of interaction between vitamin C levels and breed on sperm morphology of rabbit bucks. There were no interactions between vitamin C levels and breed for normal and abnormal sperm, tailless head, rudimentary tail, narrow head, stump tail, round double tail, ruffle acrosomes, bent tail, coiled tail, dag defect, curved mid piece, bent mid piece, proximal cytoplasmic droplet, mid piece droplet, tail opening droplet translocation, double head neck and flagellum, and double head single neck and flagellum and round cell ($p>0.05$). There was interaction between vitamin C levels and breed on Pyriform ($p<0.05$). Pyriform was high and low at crossbred bucks fed 300 and 400mg vitamin C. Similarly, there was interaction

between vitamin C levels and breed on translocation cytoplasmic droplet ($p<0.05$). Translocation cytoplasmic droplet was high at crossbred bucks fed 300 mg, low at pure and crossbred fed 400 mg vitamin C level.

4.34 Effect of Interaction between Vitamin C levels and Season on Sperm morphology of Rabbit Buck

Table 4.27 shows the effect of interaction between vitamin C levels and season on sperm morphology of rabbit bucks. There were no interactions between vitamin C levels and season on all the parameters measured.

4.35 Effect of Interaction between Vitamin C levels and Month on Sperm Morphology of Bucks

Figure 8 shows the effect of interaction between vitamin C levels and month on sperm morphology of rabbit bucks. There were no interactions between vitamin C levels and month in all parameters measured except for tailless head, pyriform and ruffle acrosome that were significant. Tailless head was significantly ($p<0.05$) higher in the month of April at bucks on 400 mg vitamin C. Pyriform significantly ($p<0.05$) higher in the month of August at 300 mg vitamin C. ruffle acrosome was significantly ($p<0.05$) higher in the month of July at 300 mg vitamin C.

Table 4.25: Effect of Month on Sperm Morphology of Rabbit Bucks Fed Diets Supplemented with Vitamin C

Parameter	April	May	June	July	August	p-v
Normal Sperm	62.82± 2.53	63.30± 2.28	65.13± 2.02	72.52 ±3.27	68.93± 3.60	0.11
Abnormal Sperm	35.03± 2.44	35.42±2.21	31.90± 1.95	27.33± 3.16	31.07±3.48	0.23
Primary Abnormalities						
Tailless Head	7.97±0.82^{a}	5.94±0.75^{c}	6.53±0.65^{b}	2.79±1.07^{e}	4.35±1.18^{d}	0.0020
Rudimentary Tail	2.79±0.38^{ab}	2.99±0.35^{a}	1.81±0.31^{b}	0.94±0.49^{c}	0.75±0.55^{d}	0.0003
Narrow Head	3.45±0.52^{c}	3.81±0.48^{b}	3.11±0.43^{d}	2.05±0.68^{e}	6.81±0.75^{a}	.0001
Stump Tail	1.36± 0.29^{b}	1.40± 0.26^{a}	1.21± 0.23^{c}	0.17± 0.37^{d}	0.10± 0.41^{e}	0.008
Ruffled acrosome	0.18±0.07	0.03± 0.06	0.06± 0.05	0.18± 0.08	0.03± 0.09	0.3
Pyriform	0.00± 0.02	-0.00± 0.01	-0.00±0.01	0.02± 0.02	0.03± 0.02	0.2
Round Double Tail	-0.00± 0.07	-0.00± 0.06	0.06± 0.05	0.06± 0.09	0.03± 0.09	0.9
Secondary Abnormalities						
Bent Tail	4.56±0.55	4.82±0.45	5.27±0.39	3.35±0.64	5.72±0.71	0.08
Coiled Tail	3.50±0.45	3.35±0.41	2.40±0.36	2.55±0.59	2.34±0.65	0.2
Proximal Cytoplasmic Droplet	0.01± 0.03^{c}	0.01± 0.03^{c}	0.01± 0.02^{c}	0.21±0.04^{a}	0.07± 0.05^{b}	0.0001
Dag Defect	0.00±0.09	-0.00±0.08	0.06±0.07	0.28 ±0.12	0.17 ±0.14	0.2
Translocation Cytoplasmic Droplets	0.05± 0.03	0.01± 0.03	0.05± 0.02	-0.00± 0.04	0.00± 0.04	0.6
TailOpening Droplet Translocation	0.03± 0.07	0.04± 0.06	0.08± 0.05	0.05± 0.09	0.03± 0.09	0.9
Double Head Neck and Flagellum	0.09± 0.11^{e}	0.18± 0.10^{d}	0.26± 0.09^{b}	0.63± 0.14^{a}	0.21±0.16^{c}	0.05
Double HSN and Flagellum	2.83± 1.74	0.17±1.58	3.09± 1.39	0.24 ± 2.25	-0.00± 2.48	0.5
Mid piece Droplet	5.60±0.51	5.29±0.46	5.36 ±0.41	5.60±0.66	4.31±0.73	0.6
Curved Mid piece	3.05±0.43	2.67±0.39	1.97±0.34	2.30±0.55	2.52±0.61	0.3
Bent Mid piece	4.76±0.46	4.77±0.42	4.31±0.37	5.52±0.60	3.50±0.66	0.2
Round Cell	0.01±0.11	0.01±0.10	0.25±0.09	0.16±0.13	0.10± 0.15	0.3

Means along rows with different superscript letters are significantly different($p<0.05$)

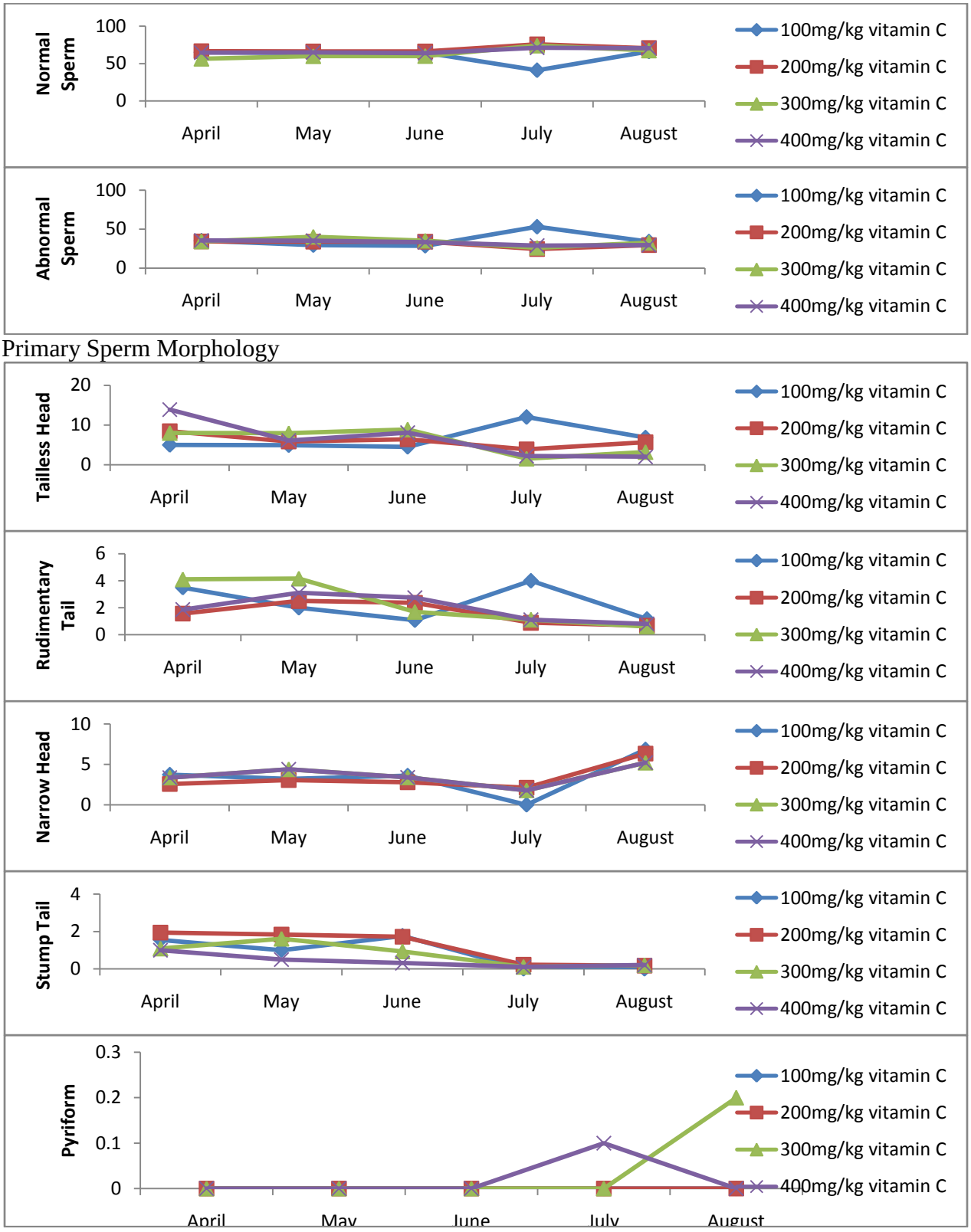
Table 4.26: Effect of Interaction between Vitamin C levels and Breed on Sperm Morphology of Rabbit Bucks

Parameters	100		200		300		400		p-v
	Pure	Cross	Pure	Cross	Pure	Cross	Pure	Cross	
Normal Sperm	65.6±2.5	69.3±4.06	68.6±2.63	65.9±3.7	59.6±2.67	57.0± 1.13	65.4±2.96	66.6±4.33	0.75
Abnormal Sperm	31.8±2.5	30.8±3.97	31.3±2.6	34.6±3.64	34.6±2.61	32.3±5.02	32.8±2.90	33.3±4.2	0.86
Primary Abnormalities									
Tailless Head	4.90±0.85	4.81±1.34	6.13±0.87	6.72±1.26	7.21±0.86	6.82±1.62	7.94±0.96	4.93±1.43	0.45
Rudimentary Tail	2.35±0.41	1.50±0.64	1.74±0.42	2.33±0.61	2.90±0.41	2.64±0.78	2.23±0.46	2.50±0.69	0.6
Narrow Head	3.50±0.53	3.44±0.84	2.55±0.54	3.17±0.79	3.13±0.54	3.82±1.01	3.23±0.60	3.21±0.89	0.9
Stump Tail	1.31±0.29	2.00±0.47	1.76±0.31	1.11±0.44	0.95±0.31	0.90±0.60	0.40±0.34	0.36±0.50	0.4
Pyriforms	0.00 ± 0.02^{c}	-0.00 ± 0.02^{d}	0.0 ± 0.02^{c}	0.0 ± 0.02^{c}	0.0 ± 0.02^{c}	0.10 ± 0.03^{a}	0.03 ± 0.02^{b}	-0.0 ± 0.03^{d}	0.03
Round Double Tail	0.14±0.07	-0.00±0.11	0.00±0.07	0.00±0.98	0.00±0.07	1.00±0.14	-0.00±0.78	-0.0±0.11	0.7
Ruffled acrosome	0.17±0.06	0.06±0.10	0.08±0.07	0.11±0.15	0.24±0.10	-0.00±0.13	-0.00±0.08	0.00±0.11	0.50
Secondary Abnormalities									
Bent Tail	4.05±0.48	4.94±0.75	5.05±0.49	4.39±0.71	4.10±0.48	5.91±0.91	4.45±0.54	4.64±0.80	0.3
Coiled Tail	3.05±0.42	2.56±0.67	2.90±0.45	4.22±0.63	2.92±0.43	2.91±0.81	1.90±0.48	2.64±0.72	0.4
Dag Defect	0.20±0.10	-0.00±0.16	-0.00±0.10	0.11±0.15	0.10±0.01	0.00±0.19	0.23±0.11	0.21±0.17	0.7
Proximal Cytoplasmic Dro	0.00±0.22	0.00±0.04	0.00±0.03	0.05±0.04	0.03±0.03	0.10±0.05	0.07±0.03	0.07±0.05	0.7
Translo Cytoplasmic Droplet	0.02 ± 0.02^{c}	0.00 ± 0.05^{d}	0.03 ± 0.03^{c}	0.05 ± 0.04^{b}	0.00 ± 0.03^{d}	0.20 ± 0.06^{a}	0.00 ± 0.03^{d}	0.00 ± 0.05^{d}	0.05
Tail Opening Droplet Trans	0.05±0.07	-0.00±0.11	0.05±0.07	0.05±0.01	0.14±0.07	0.00±0.14	0.17±0.08	0.00±0.12	0.8
Double HNF	0.24±0.11	0.50±0.18	0.05±0.12	0.21±0.16	0.11±0.12	0.30±0.23	0.27±0.13	0.36±0.19	0.96
Double HSNF	0.17±1.70	0.31±2.75	0.08±1.79	0.11±2.52	6.30±1.81	11.40±3.40	2.00±2.00	0.07±2.94	0.6
Bent Mid piece	3.90±0.46	3.38±0.72	4.58±0.47	4.72±0.68	5.33±0.46	6.09±0.87	5.48±0.52	4.93±0.77	0.7
Mid piece Droplet	5.80±0.51	5.44±0.81	4.71±0.53	4.89±0.77	5.26±0.52	5.82±0.98	5.42±0.58	6.07±0.87	0.9
Round Cell	0.18±0.11	0.25±0.18	0.13±0.12	0.00±0.17	0.21±0.11	0.00±0.21	0.07±0.13	0.071±0.2	0.8
Curved Mid piece	2.18±0.44	1.75±0.69	1.71±0.45	2.56±0.66	2.54±0.45	4.18±0.84	2.84±0.50	3.29±0.74	0.4

Means along a row with different superscript letters are significantly different ($p<0.05$)

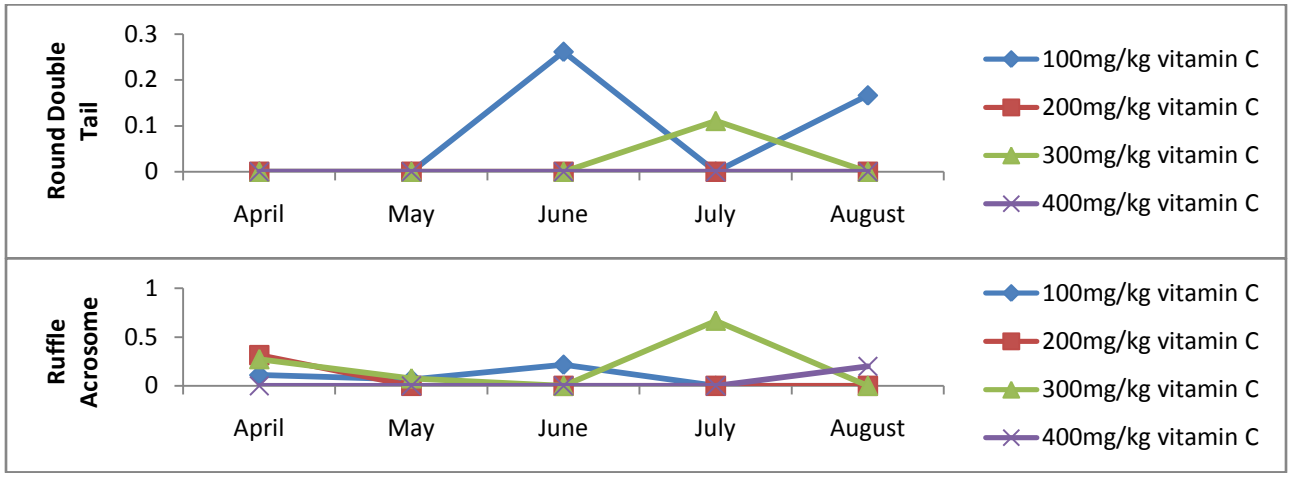
Table 4.27: Effect of Interaction between Vitamin C levels and Season on Sperm Morphology of Rabbit Bucks

Parameters	100		200		300		400		P-V
	Hot-Dry	Cool-Wet	Hot-Dry	Cool-Wet	Hot-Dry	Cool-Wet	Hot-Dry	Cool-Wet	
Normal sperm	64.46±2.81	69.52±3.24	66.29±2.77	69.84±3.37	57.96±3.37	60.12±3.30	64.75±4.0	66.39±3.06	0.95
Abnormal sperm	32.51±2.74	30.12±3.15	34.00±2.70	30.17±3.28	37.56±3.28	30.79±3.21	35.25±3.9	31.71±2.96	0.9
Primary Abnormalities:									
Tailless Head	5.16±0.96	4.52±1.06	7.06±0.91	5.19±1.14	7.96±1.09	6.35±1.04	8.75±1.33	6.03±0.99	0.8
Rudimentary Tail	2.93±0.44	1.08±0.49	2.06±0.42	1.73±0.52	4.12±0.50	1.65±0.48	2.56±0.62	2.17±0.46	0.08
Narrow Head	3.39±0.60	3.60±0.67	2.82±0.57	2.64±0.71	3.92±0.68	2.69±0.65	3.81±0.83	2.90±0.62	0.7
Stump Tail	1.31±0.29	2.00±0.47	1.74±0.36	1.10±0.43	0.95±0.31	0.90±0.60	0.40±0.34	0.36±0.50	0.2
Pyriform	0.00±0.02	0.00±0.02	0.00±0.02	0.00±0.022	0.00±0.02	0.10±0.03	0.03±0.0	0.00±0.11	0.6
Round Double Tail	0.14±0.07	0.00±0.07	0.00±0.07	0.00±0.10	0.00±0.07	0.10±0.14	0.00±0.78	0.00±0.11	0.4
Ruffle acrosomes	0.17±0.06	0.06±0.10	0.08±0.07	0.11±0.10	0.24±0.07	0.00±0.13	0.00±0.08	0.00±0.11	0.43
Secondary Abnormalities									
Bent Tail	4.29±0.54	4.32±0.61	4.47±0.52	5.41±0.65	4.50±0.62	4.50±0.59	4.25±0.75	4.66 ±0.56	0.8
Coiled Tail	3.29±0.48	2.44±0.53	3.88±0.47	2.45±0.57	3.21±0.55	2.65±0.52	2.06±0.67	2.17±0.5	0.6
Dag Defect	0.07±0.11	0.24±0.13	0.00±0.11	0.09±1.33	0.13±0.13	0.04±0.12	0.25±0.11	0.21±0.12	0.7
Proxi Cytoplasmic Droplet	0.00±0.03	0.00±0.04	0.00±0.03	0.05±0.04	0.03±0.03	0.10±0.05	0.07±0.03	0.07±0.05	0.4
Transl Cytoplasmic Droplet	0.024±0.03	0.00±0.05	0.03±0.03	0.05± 0.04	0.00±0.03	0.20±0.06	0.00±0.33	0.00±0.05	0.25
Tail Opening Droplet Tran	0.05±0.07	0.00± 0.11	0.05±0.07	0.05± 0.01	0.14±0.07	0.00±0.14	0.17±0.08	0.00±0.12	0.3
Double H NF	0.27±0.13	0.36±0.144	0.03±0.123	0.22±0.15	0.09±0.150	0.21±0.15	0.38±0.18	0.25±0.14	0.8
Double HSNF	0.18±1.92	0.24±2.20	0.03±1.89	0.17.±2.29	5.13±2.29	9.54±2.25	0.13±2.75	2.11±2.08	0.7
Mid piece Droplet	5.87±0.58	5.48±0.65	4.71±0.56	4.86±0.69	5.63±0.66	5.15±0.64	4.75±0.81	6.10±0.60	0.5
Bent Mid piece	3.68±0.52	3.84±0.58	4.76±0.5	4.41±0.62	5.50±0.59	5.50±0.57	5.63±0.73	5.14±0.54	0.9
Round Cell	0.00±0.13	0.44±0.14	0.03±0.12	0.18± 0.15	0.04±0.14	0.27±0.14	0.00± 0.18	0.10±0.13	0.6



Primary Sperm Morphology

Figure 8: Effect of Interaction between Vitamin C levels and Month on Sperm Morphology of Rabbit Bucks



Secondary Sperm Morphology

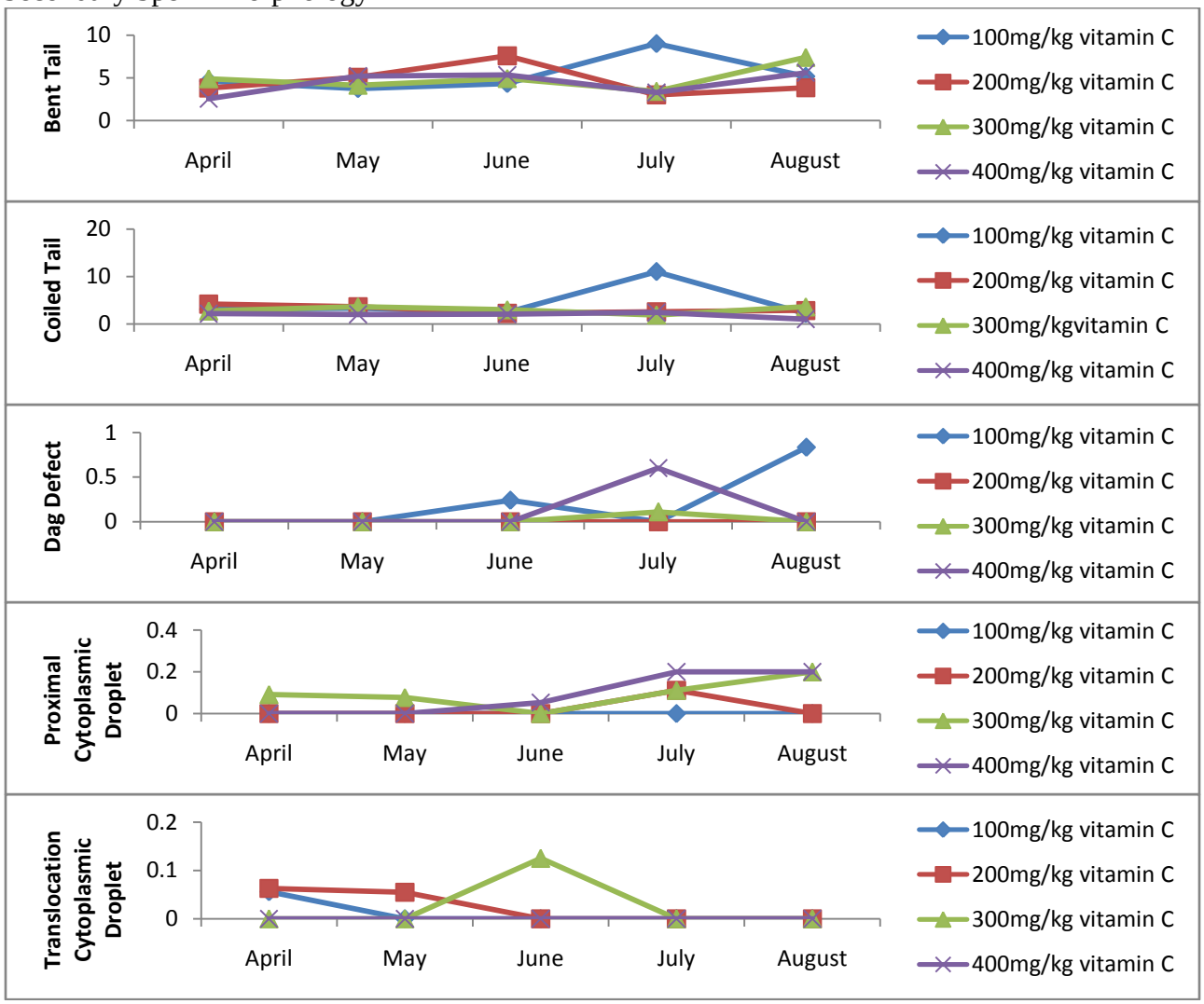


Figure 8 (continuation): Effect of Interaction between Vitamin C levels and Month on Sperm Morphology of Rabbit Bucks

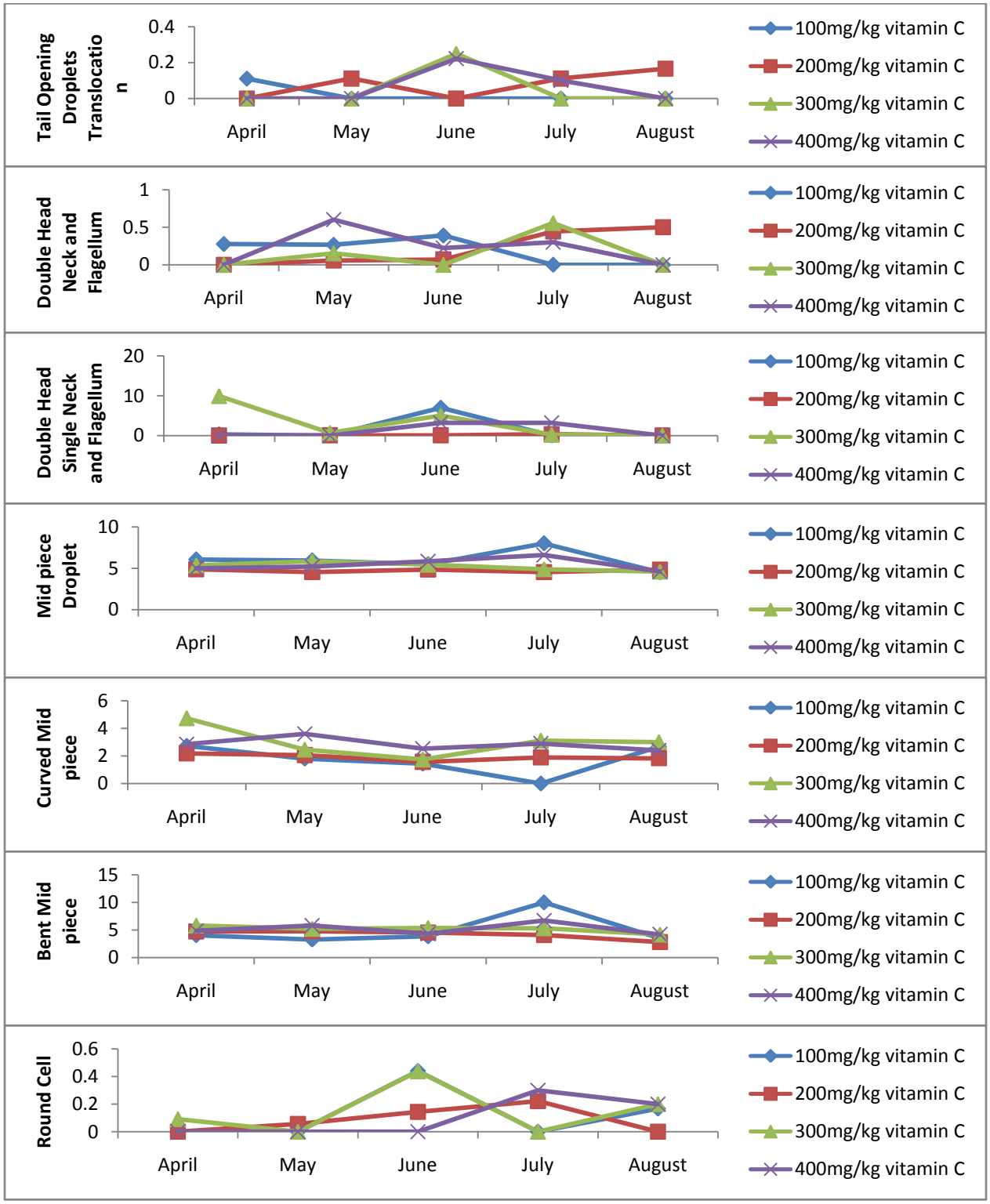


Figure 8 (continuation): Effect of Interaction between Vitamin C levels and Month on Sperm Morphology of Rabbit Bucks

4.36 Effect of Interaction between Breed and Season on Sperm Morphology of Rabbit Bucks

Table 4.28 shows the effect of interaction between breed and season on sperm morphology of rabbit bucks. There was no interaction between breed and season on normal and abnormal sperm, tailless head, rudimentary tail, curved mid piece, bent mid piece, mid piece droplet, coiled tail, narrow head, round cell, dag defect, proximal droplet, stunned tail, round double tail, pyriform, ruffle acrosomes, translocation cytoplasmic droplet, tail opening droplet translocation, and double head single neck and flagellum among season and breed. There was interaction between breed and season on bent tail ($p<0.05$). Bent tail increased and decreased at crossbred during hot dry and cool wet season. There was interaction between breed and season on double head neck and flagellum ($p<0.05$). Double head neck and flagellum was high at crossbred and low at purebred during cool wet season.

4.37 Effect of Interaction between Breed and Month on Sperm Morphology of Rabbit Bucks

Figure 9 shows the effect of interaction between breed and month on sperm morphology of rabbit bucks. There were no interactions between breed and month in all parameters measured except for proximal cytoplasmic droplet that was significant. Proximal cytoplasmic droplets significantly ($p<0.05$) increased and decreased in a similar pattern between breed and month except in the month of August that it increased for purebred.

Table 4.28: Effect of Interaction between Breed and Season on Sperm Morphology of Rabbit Bucks Fed Diets Supplemented with Vitamin C

Parameters	Pure		Cross		p-v
	Hot - Dry	Cool - Wet	Hot - Dry	Cool - Wet	
Normal Sperm	64.49±1.86	65.24±1.95	61.52±3.0	69.30±2.9	0.2
Abnormal Sperm	33.49±1.78	31.60±1.9	37.17±2.9	28.73±2.8	0.2
Primary Abnormalities					
Tailless Head	7.09±0.62	5.81±0.63	6.63±0.98	4.93±0.10	0.8
Rudimentary Tail	2.77±0.29	1.84±0.29	3.10±0.46	1.28±0.47	0.3
Narrow Head	3.09±0.38	3.11±0.39	4.13±0.60	2.59±0.61	0.1
Stump Tail	1.39±0.22	0.87±0.23	1.41±0.36	0.87±0.35	0.96
Round Double Tail	0.00±0.05	0.09±0.05	0.00±0.08	0.03±0.08	0.69
Pyriform	0.00±0.01	0.01±0 01	0.00±0.02	0.03±0.02	0.53
Ruffled acrosomes	0.13±0.05	0.13±0.05	0.07±0.08	0.03±0.08	0.8
Secondary Abnormalities					
Bent Tail	3.95 ± 0.34^{d}	4.88 ± 0.35^{b}	5.50 ± 0.54^{a}	4.24 ± 0.55^{c}	0.02
Coiled Tail	3.07±0.0.3	2.40±0.31	3.80±0.49	2.48±0.50	0.4
Dag Defect	0.12±0.07	0.14±0.07	0.00±0.11	0.02±0.12	0.4
Proximal Cytoplasmic Droplet	0.01±0.02	0.03±0.02	0.00±0.03	0.10±0.03	0.10
Translocation Cytoplasmic Droplet	0.03±0.02	0.00±0.02	0.03±0.03	0.07±0.03	0.3
Tail Opening Droplet Translocation	0.04±0.05	0.16±0.05	0.03±0.08	0.00±0.08	0.2
Double Head Neck and Flagellum	0.21 ± 0.08^{b}	0.11 ± 0.08^{c}	0.07 ± 0.13^{d}	0.60 ± 0.13^{a}	0.004
Double Head Single Neck and Flagellum	0.96±1.29	3.27±1.35	1.83±2.10	2.30±2.06	0.6
Round Cell	0.03±0.08	0.27±0.08	0.00±0.13	0.17±0.13	0.7
Mid piece droplet	5.16±0.38	5.44±0.38	5.33±0.59	5.45±0.60	0.7
Curved Mid piece	2.56±0.32	2.01±0.33	3.33±0.51	2.28±0.52	0.6
Bent Mid piece	4.67±0.34	4.90±0.35	4.93±0.54	4.38±0.55	0.4

Means along a row with different superscript letters are significantly different ($p<0.05$)

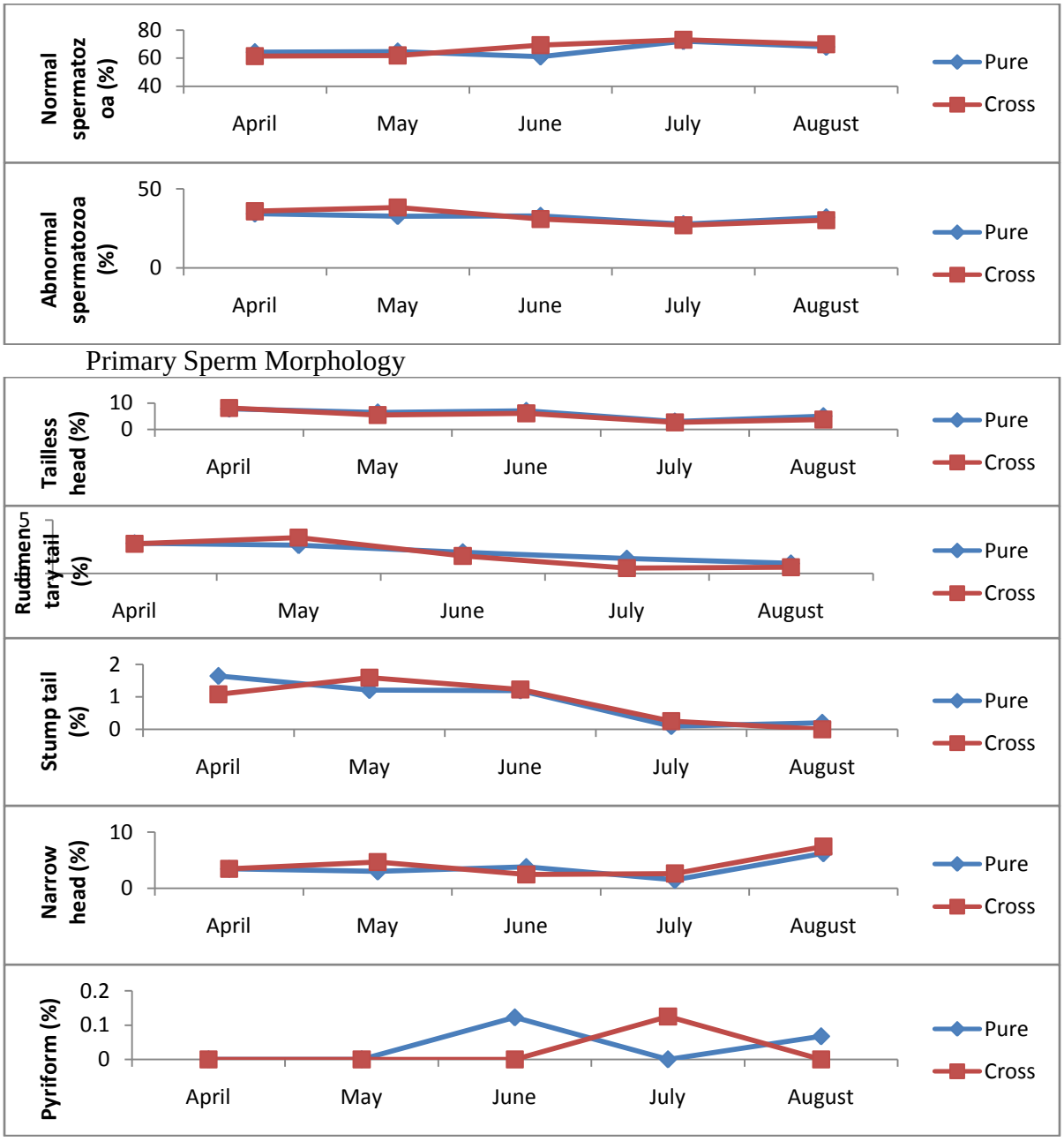
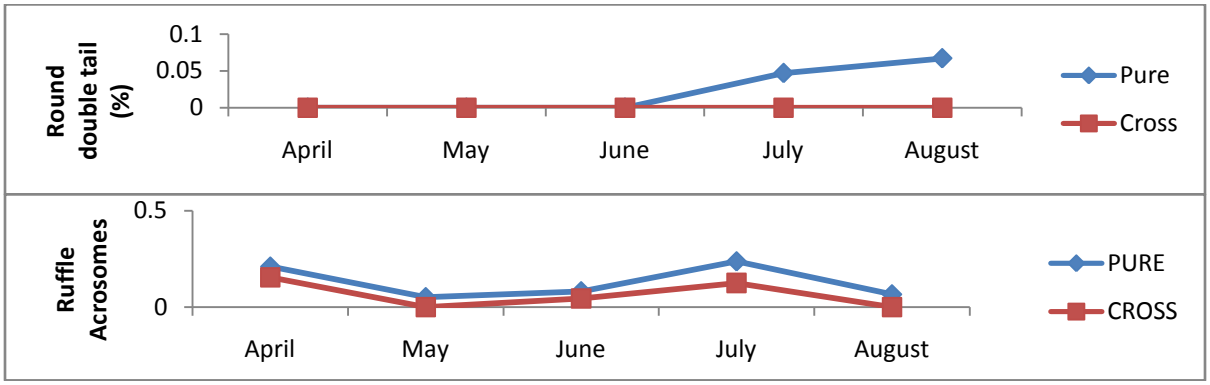


Figure 9: Effect of Interaction between Breed and Month on Sperm Morphology of Rabbit Bucks



Secondary Sperm Morphology

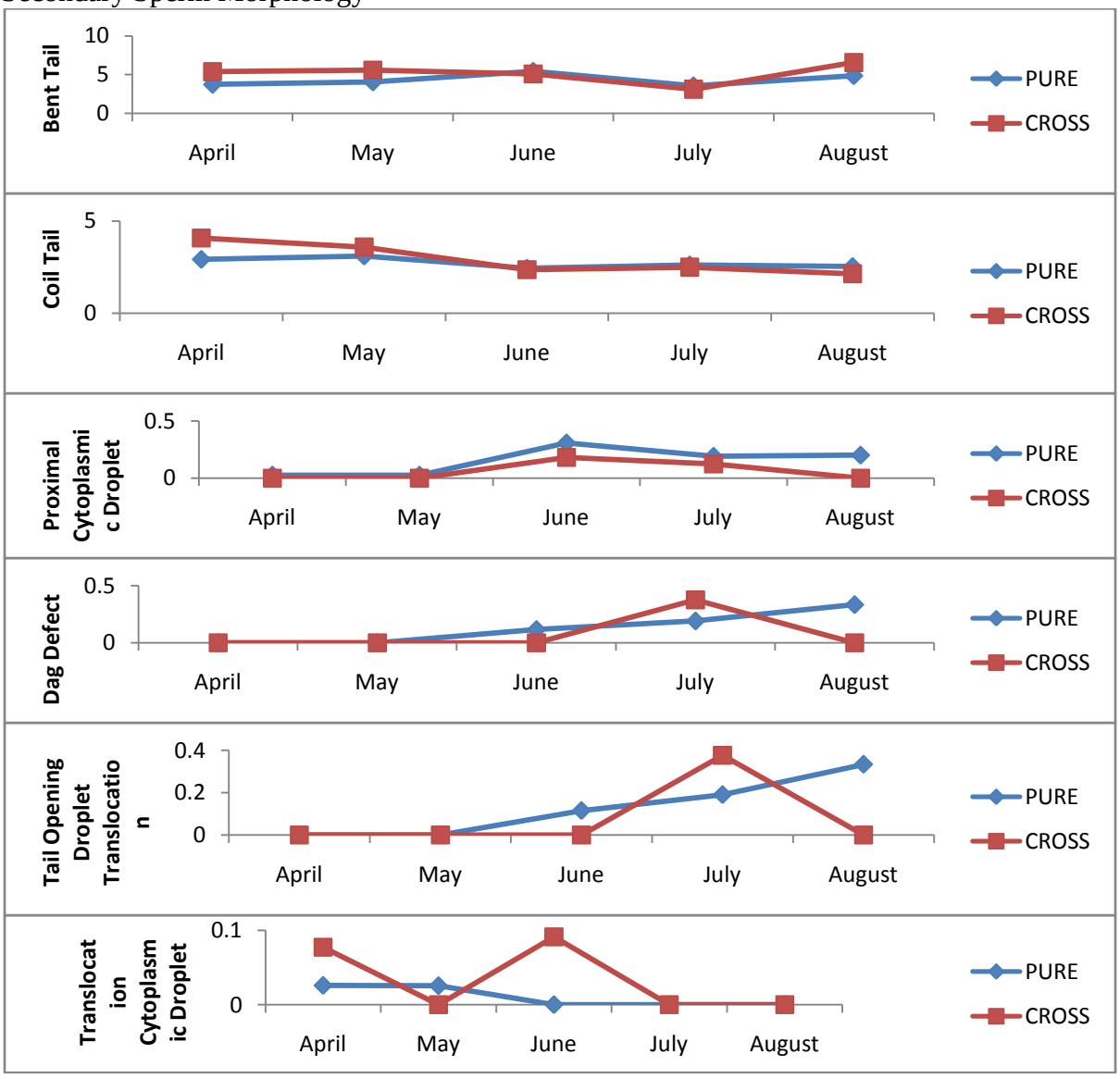


Figure 9 (continuation): Effect of Interaction between Breed and Month on Sperm Morphology of Rabbit Bucks

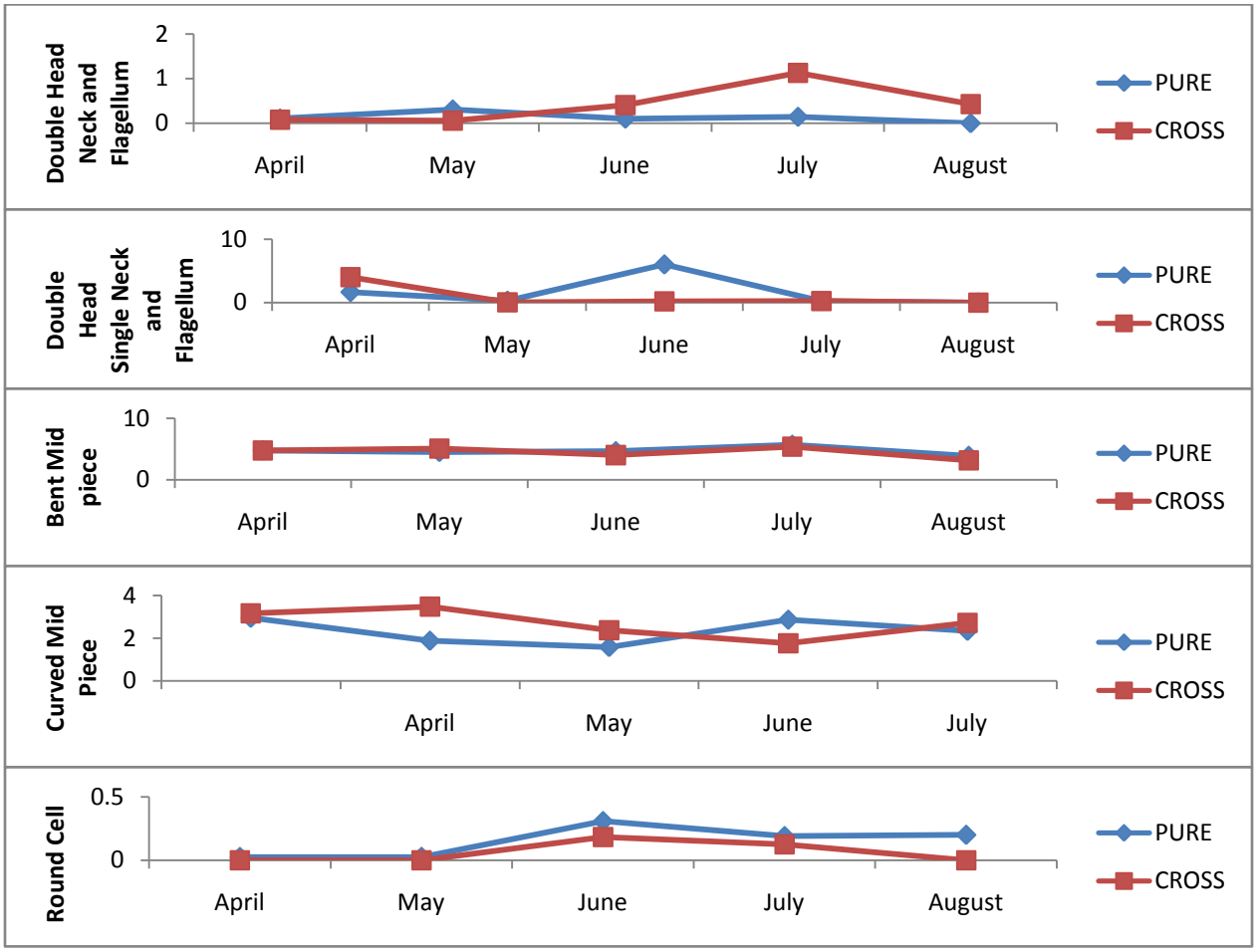


Figure 9 (continuation): Effect of Interaction between Breed and Month on Sperm Morphology of Rabbit Bucks

CHAPTER FIVE

5.0 DISCUSSION

5.1 EFFECT OF VITAMIN C LEVELS ON GROWTH PERFORMANCE OF RABBIT BUCKS

The significant increase in feed intake of rabbit bucks fed 400mg/kg vitamin C level in table 4.1, could be an indication that high level of vitamin C increases feed intake, which is in agreement with the findings of Gross (1988) who reported appreciable improvement in feed intake of rabbits fed vitamin C supplemented diet. It also agrees with the findings of Afify and Makled (1995) who reported that feed intake of rabbits increased with increase in vitamin C level of inclusion in diet. Tuleun *et al.* (2011) did not observe significant differences in feed intake of quails fed vitamin C.

The highly significant increase in water intake by rabbit bucks fed 400mg vitamin C level in table 4.1, showed that vitamin C enhances water intake which agrees with the results of Adenkola *et al.,* (2010) and Gross (1988) which showed that vitamin C enhances rate of water intake of rabbits. This result does not agree with Tuleun *et al.* (2011) who reported that there were no significant variations in water consumption of quails fed graded levels of vitamin C supplemented diet. The significant increase of right scrotal circumference of rabbit bucks fed 400 mg vitamin C level in table 4.1 may be said that high vitamin C levels increased the size of scrotum.

5.2 EFFECT OF BREED ON GROWTH PERFORMANCE OF RABBIT BUCKS FED VITAMIN C SUPPLEMENTED DIET

The significant increase of feed intake in crossbred than purebred bucks observed in this study in table 4.2 could be attributed to heterosis, and does not agree with the reports of McLaren *et al.*(1987) and El-Medany *et al.*(2012) who reported no significant variation in feed intake between purebred and crossbred animals, also Ilorie *et al.* (2010) reported that feed intake of crossbred was not significantly higher than purebreds. This result agrees with the finding of

Abdel-Azeem *et al.* (2007) who reported that feed intake of crossbred rabbits were significantly higher than purebred, and attributed this to heterosis in crossbred over purebreds.

The highly significant water consumption of purebred over crossbred bucks in table 4.2 could be attributed to stress which is in agreement with Ilorie *et al.*(2010) who reported that purebreds consumed more water than crossbred because they are easily stressed, therefore, the increase in water consumption is to compensate for water loss, increase the frequency of heat dissipation capacity in order to avoid dehydration (Belay *et al*., 1992), to increase plasma expansion, reduce plasma osmolality and whole blood viscosity (Zhou *et al*., 1999)**.**

The significant difference in left scrotal circumference between pure and crossbred bucks in table 4.2 could be linked to genetic differences and it agrees with the reports of Ugwu *et al.* (2009) and Wilson *et al.* (1977) who reported that scrotal circumference and testicular size are significantly different between breed. The significant difference in response time between pure and crossbred observed in table 4.2 could be attributed linked to purebred susceptible to stress which agrees with the report of Seleem *et al.* (2008) who reported that libido of purebred were significantly higher than crossbred rabbits and disagreed with McLaren *et al.* (1987) who reported that crossbred animals possess greater libido than purebreds.

5.3 EFFECT OF SEASON ON GROWTH PERFORMANCE OF RABBIT BUCKS FED VITAMIN C SUPPLEMENTED DIETS

The highly significant increase in feed intake during cool wet season and a decrease in hot dry season observed in table 4.3 could be attributed to low ambient temperature and high ambient relative humidity which occurred in the cool wet season, it is in agreement with Marai *et al.* (2001) who reported a significant decrease in feed intake of rabbit bucks in hot dry season and

an increase in feed intake in cool wet season. The significant increase of water intake of bucks in the hot dry season observed in table 4.3 may be linked to stress which increases in hot dry season compared to cool wet season as a mechanism to regulate heat stress and maintain body water balance to avoid dehydration (Nagy and Cost, 1980).

The highly significant reduction in weight in hot dry season observed in table 4.3 may be attributed to high ambient temperature and low ambient relative humidity it is in agreement with Marai *et al.*(2002) who reported that live body weight and daily body weight gain of rabbits decreased in the hot dry season due to heat stress, attributive to the negative effect on appetite center which causes decrease in feed consumption while in the cool wet season live body weight and daily body weight gain increases, which may be linked to a positive feedback mechanism to the appetite center for high feed consumption.

The highly significant variation of both left and right scrotal circumference in cool wet and hot dry season agrees observed in table 4.3 may be attributed to contraction of tunica dartos and cremaster muscle in the scrotum, this agrees with the reports of Zeidan and Abbas, (2004) in Maiada *et al.*(2013) who reported that hot dry season which expressed heat stress, decreases scrotal circumference, while cool wet or rainy season increases scrotal circumference, high ambient temperature which occurs during the hot dry season causes pendulous arrangement of the scrotum and decreases the wrinkling nature of the scrotal epithelium (Zeiddan *et al.*,2001).

5.4 EFFECT OF MONTH ON GROWTH PERFORMANCE OF RABBIT BUCKS FED VITAMIN C SUPPLEMENTED DIET

The highly significant difference in feed intake of rabbit bucks in the month of August observed in table 4.4 could be attributed to low ambient temperatures in the morning and afternoon, and

high ambient relative humidity which increases metabolic rate, this agrees with Marai *et al.* (2001). The highly significant increase in water intake of bucks in the month of March observed in table 4.4 indicates that the rabbits were stressed and may be attributed to the need to maintain water and electrolyte balance which is reduced during excretion of urine and faeces (Belay and Teeter 1996) and during panting especially in the months of March, April, and May which are characterized with high ambient temperature and low relative humidity.

The significant increase of weight in the month of July and August observed in table 4.4 may be attributed to high ambient relative humidity and low ambient temperature which could trigger feed efficiency this supports the report of Marai *et al.* (2002). The highly significant difference of the left and right scrotal circumference in the month of August and September observed in table 4.4 may be attributed to the contraction of tunica dartos and cremaster muscles in the period of low ambient temperature and high relative humidity which is in union with the report of Zeidan and Abbas (2004) who reported that larger scrotal size in the cool wet season. The significant long reaction time in the month of September observed in table 4.4 may be attributed to high ambient relative humidity and low ambient temperature.

5.5 EFFECT ON INTERACTION BETWEEN VITAMIN C LEVELS AND BREED ON GROWTH PERFORMANCE OF RABBIT BUCKS

The significant increase in feed intake by purebred bucks fed 400 mg vitamin C, on interaction between vitamin C levels and breed observed in table 4.5 may be stated that high vitamin C level enhanced feed intake in purebred which are easily stress than crossbred which agrees with the report of Alhassan *et al.* (2010) who reported that vitamin C improve feed intake. The significant increase in water intake by purebred fed 400 mg vitamin C, on interaction between vitamin C levels and breed observed in table 4.5 could be said that high vitamin C level increase water

intake in purebred. The increase in size of left and right scrotal circumference observed on table 4.5 may be said that vitamin C improved scrotal circumference of bucks.

5.6 EFFECT OF INTREACTION BETWEEN VITAMIN C LEVELS AND MONTH ON GROWTH PERFORMANCE OF RABBIT BUCKS

The significant increase in weight gain of bucks in the months of June and July in all vitamin C levels observed in figure 2 may be attributed to low ambient temperature and high relative humidity. The significant increase in water intake of rabbit bucks in the month of March in all vitamin C levels observed in figure 2 may be attributed to high ambient temperature and an increase in ambient relative humidity that imposed stress on the bucks. The significant long reaction time of bucks fed 100 mg vitamin C in the month of March as observed in figure 2 may be attributed to low vitamin C level and could state that 100 mg vitamin C is inadequate to ameliorate stress.

5.7 EFFECT OF INTERACTION BETWEEN BREED AND SEASON ON GROWTH PERFORMANCE OF RABBIT BUCK

The significant increase in weight gain of purebred bucks in cool wet season as observed in table 4.7 may be attributed to genetic differences between breed, and could state that purebred are superior to crossbred in weight gain. The significant increase in scrotal size of purebred than crossbred bucks as observed in table 4.7 may also be attributed to genetic variations which agrees with the reports of Ugwu *et al.*(2009) who reported that scrotal circumference is breed dependent.

5.8 EFFECT OF INTERACTION BETWEEN MONTH AND BREED ON GROWTH PERFORMANCE OF RABBIT BUCKS

The significant increase in feed intake of bucks in the months of May to August as shown in figure 3 may be attributed to low ambient temperature and high relative humidity which increases metabolic activities and the stimulation of peripheral thermal receptors to transmit suppressive

nerve impulse to the appetite centre in the hypothalamus to increased feed intake (Marai and Habeeb, 1988).

The significant increase of weight gain in the month of July for both pure and crossbred bucks as shown in figure 3 may be attributed to low ambient temperature and high ambient relative humidity which promote feed efficiency and conversion ratio. The significant increase in right scrotal circumference of pure and crossbred bucks in the months of August and September as shown in figure 3 could be attributed to the contraction of tunica dartos and cremaster muscle for efficient scrotal thermoregulation which during low ambient temperature and high relative humidity.

5.9 EFFECT OF VITAMIN C LEVELS ON THERMOREGULATORY PARAMETERS OF RABBIT BUCKS

The significant increase in rectal temperature of bucks fed graded vitamin C levels as shown in table 4.8 may be attributed to low vitamin C levels this implies that 100 mg vitamin C level is inadequate and cannot ameliorate rectal temperature in rabbit bucks.

5.10 EFFECT OF SEASON ON THERMOREGULATORY PARAMETERS OF RABBIT BUCKS

The significant increase of skin temperature in cool wet season as shown in table 4.10 could be attributed to low ambient temperature and high ambient relative humidity which increase heat load on the bucks due to high metabolic activities to maintain thermal balance by adjusting skin temperature to ambient temperature. This does not agree with Zeferino *et al.*, (2011) who reported that high ambient temperature increases skin temperature of rabbits, but agreed with Willmer and Johnstone (2005) who reported high metabolic rate in cool wet than hot dry season.

The significant increase of ear temperature in the hot dry season as shown in table 4.10 could be as a mechanism to regulate heat stress, it agrees with Fayez *et al*. (1994) who reported that ear

temperature increases during hot dry season as a result of heat dissipation through radiation, convection, and evaporation to environment. The increase in heat loss through this medium is occasioned by the lower relative humidity observed in this season compared to high relative humidity in the cool wet season that does not allow easy evaporative, radiative or convective heat loss. The significant increase of scrotal temperature in the hot dry season as shown in table 4.10 may be attributed increased ambient temperature.

The significant increase of rectal temperature in hot dry season as shown in table 4.10 may be linked to high ambient temperature expressed in hot dry season, this agrees with Ganaie *et al.* (2013) and Iyeghe *et al.* (1993) who reported high rectal temperature of weaned rabbit during hot dry than cool wet season. The significant increase of respiratory rate in the hot dry season as indicated in table 4.10 could be linked to high ambient temperature and low ambient relative humidity which induces heat stress, this agrees with Ganaie *et al.*(2013) who reported that respiratory rate increases when ambient temperature increased. The significant increase of heart rate of rabbit bucks in the hot dry season as indicated in table 4.10 could be linked to stress, it agrees with Ganaie *et al.* (2013) who reported that heart rate increases when environmental temperature increase and reduces as the environmental temperature decreased.

5.11 EFFECT OF MONTH ON THERMOREGULATORY PARAMETERS OF RABBIT BUCKS

The significant increase of skin temperature in month of September as shown in table 4.11 could be linked to low ambient temperature and high ambient relative humidity which may influence high metabolic activities to maintain thermal equilibrium this is line with Willmer and Johnstone (2005) who reported high metabolic activities in cool wet season.

The significant increase of ear temperature in the month of March as shown in table 4.11 could be as a mechanism to regulate heat stress through radiation, convection, and evaporation heat dissipation to environment and may be attributed to high ambient temperatures and low ambient relative humidity it is line with Fayez *et al*. (1994). The significant increase of scrotal temperature in month of March as shown in table 4.11 could be attributed to high ambient temperature and low ambient relative humidity.

The significant increase of rectal temperature from the month of March as shown in table 4.11 could be linked to high ambient temperature and low relative humidity which is in line with Ganaie *et al.* (2003) and Iyeghe ***e****t al.* (1993). The significant increase of respiratory rate in the month of March as shown in table 4.11 could be mechanism to regulate heat stress due to high ambient temperature and low ambient which is in line with Ganaie *et al.* (2013).The significant increase of heart rate in month of March as shown in table 4.11 could be attributed to high ambient temperature and low ambient humidity which induces heat stress on the animals, this result is in line with Ganaie *et al.* (2013).

5.12 EFFECT OF INTERACTION BETWEEN VITAMIN C LEVELS AND BREED ON THERMOREGULATORY PARAMETERS OF RABBIT BUCKS

The significant increase of rectal temperature in crossbred fed 300 mg vitamin C level as shown in table 4.12 may be crossbred bucks do not utilized 300 mg vitamin C level are less susceptible to heat stress and more adaptive to the environment.

5.13 EFFECT OF INTERACTION BETWEEN VITAMIN C LEVELS AND SEASON ON THERMOREGULATORY PARAMETERS OF RABBIT BUCKS

The significant increase of respiratory rate of bucks in hot dry season fed 100 mg vitamin C as shown in table 4.13 may be state that 100 mg vitamin is inadequate to ameliorate heat stress imposed on the animal in the hot dry season.

5.14 EFFECT OF INTERACTION BETWEEN VITAMIN C LEVELS AND MONTH ON THERMOREGULATORY PARAMETERS

The significant increase of ear temperature in the month of September as shown in figure 4 may be attributed to heat load on the animal due to high ambient relative humidity which reduces the rate of heat dissipation from the animal to the environment.

The significant increase of ear temperature in bucks fed 300 and 400 mg vitamin C levels as shown in figure 4 could be attributed to inability of bucks to utilized high vitamin C level. The significant increase of heart rate in bucks fed 100 mg vitamin C as shown in figure 4 could be 100 mg vitamin C is inadequate to ameliorate heart rate in bucks. The significant increase of respiratory rate in March as shown in figure 4 could be attributed to high ambient temperature and low relative humidity.

5.15 EFFECT OF INTERACTION BETWEEN BREED AND SEASON ON THERMOREGULATORY PARAMETERS OF RABBIT BUCKS

The significant increase in rectal temperature of purebred bucks in hot dry season as shown in table 4.14 could be state that purebred bucks are more susceptible to heat stress which is expressed in the hot dry season.

5.16 EFFECT OF INTERACTION BETWEEN BREED AND MONTH ON THERMOREGULATORY PARAMETERS OF RABBIT BUCKS

The significant increase of rectal temperature in pure and crossbred bucks in the month of March as shown in figure 5 may be attributed to high ambient temperature and indicate that both breed were stress.

5.17 EFFECT OF VITAMIN C LEVELS ON SEMEN CHARACTERISTICS OF RABBIT BUCKS

The significant difference of live sperm of rabbit bucks fed 400 mg vitamin C level as shown in table 4.15 could be high vitamin C level increased live sperm, this result disagrees with Fazeli *et al.* (2010) who reported that there is no variation in live spermatozoa among dosage of vitamin C levels.

5.18 EFFECT OF BREED ON SEMEN CHARACTERISTICS OF RABBIT BUCKS

The significant increase of live sperm in crossbred than purebred as shown in table 4.16 may be attributed genetic differences, which agrees with the report of Khalil (1996) who reported that crossbred rabbit bucks has higher live sperm per ejaculate than purebred buck, could also be said that crossbred are superior to purebred.

5.19 EFFECT OF SEASON ON SEMEN CHARACTERISTIC OF RABBIT BUCKS

The significant increase of semen volume of bucks in the hot dry season as shown in table 4.17 may be attributed to counter current heat exchange mechanism in the paminiform plexus, this result do not agree with the reports of McDaniel *et al.* (1996) and Obidi *et al.* (2008) who reported a significant reduction in semen volume during the hot dry season, and the reports of Sarder *et al.* (2007) who reported that semen volume is not seasonally influenced. The significant difference of live sperm among season as shown in table 4.17 may be influenced by low ambient temperature expressed in cool wet season, it agreed with the report of El-Tohamy *et al.* (2012)

who reported that there is a significant increase of live sperm in cool wet season than hot dry season.

5.20 EFFECT OF MONTH ON SEMEN CHARACTERISTICS OF RABBIT BUCKS

The significant increase of semen motility in the month of June as shown in table 4.18 may be attributed to low ambient temperature and high relative humidity, this result is in union with the report of Al-Ghalban *et al.* (2004) who reported highly significant decrease of sperm motility from the month March to May and increase from the month June to August. The significant increase of semen volume in the month of April as shown in table 4.18 may be attributed to counter current heat exchange mechanism in the paminiform plexus which is not in line with Sarder *et al.* (2007).

The significant increase of semen colour in month of April as shown in table 4.18 could be linked to high ambient temperature and low ambient relative humidity, this result is in line with the reports of Rai *et al.* (1997) who reported variation in semen colour in hot dry season. The significant increase of live sperm in month of August as shown in table 4.18 could be attributive to low ambient temperature this result is in line with El-Tohamy *et al.* (2012).

5.21 EFFECT OF INTERACTION BETWEEN VITAMIN C LEVELS AND SEASON ON SEMEN CHARACTERISTICS OF RABBIT BUCKS

The significant increase of semen colour of bucks fed 400 mg vitamin C in hot dry season as shown in table 4.20 may be attributed to the inability of bucks to utilize high level of vitamin C.

5.22 EFFECT OF VITAMIN C LEVELS ON SPERM MORPHOLOGY OF RABBIT BUCKS

The significant increase of stump tail in bucks fed 100 mg vitamin C as shown in table 4.22 may be 100 mg vitamin C is inadequate to ameliorate stump tail. The significant increase of bent mid

piece and double head single neck and flagellum in bucks fed 300 mg vitamin C as shown in table 4.22 may be state that rabbit bucks fed 300 mg vitamin C do not effectively utilized 300 mg vitamin C level.

5.23 EFFECT OF SEASON ON SPERM MORPHOLOGY OF RABBIT BUCKS

The significant increase of abnormal sperm in hot dry season as shown in table 4.24 may be attributed high ambient temperature which may affect the caudal part of the epididymis. The significant increase of tailless head and rudimentary tail in hot dry season as shown in table 4.24 may be attributed to high ambient temperature which may affect seminiferous tubules, thus altering spermiogenesis. The significant increase of curved mid piece in hot dry season as shown in table 4.24 could be attributed to high ambient temperature which may affect corpus part of the epididymis. The significant increase of round cell in cool wet season may be attributed to high core body and scrotal temperature which may affect spermatogenesis.

5.24 EFFECT OF MONTH ON SPERM MORPHOLOGY OF RABBIT BUCKS

The significant increase of tailless head, rudimentary tail, and stump tail in the months of April and May as shown in table 4.25 may be attributed to high ambient temperature which may affect seminiferous tubule and cause changes in spermiogenesis.

The significant increase of Narrow head in the month of August may be linked to high core body and scrotal temperature which may affect spermiogenesis. The significant increase of proximal cytoplasmic droplets and double head neck and flagellum in the month of July as shown in table 4.25 could be linked to high core body and scrotal temperature which could affect the epididymis function.

5.25 EFFECT OF INTERACTION BETWEEN VITAMIN C LEVELS AND BREED ON SPERM MORPHOLOGY OF RABBIT BUCKS

The significant increase of pyriform in crossbred bucks fed 300 mg vitamin C as shown in table 4.26 could be said that crossbred bucks do not utilized 300 mg vitamin C. The significant increase of translocation cytoplasmic droplets in crossbred fed 300 mg vitamin C could be state that crossbred bucks do not tolerate high vitamin C level.

5.26 EFFECT OF INTERACTION BETWEEN VITAMNIN C LEVELS AND MONTH ON SPERM MORPHOLOGY OF RABBIT BUCKS

The significant increase of tailless head, pyriform and ruffle acrosome in bucks fed 400 and 300 mg vitamin C in April, July and August respectively as shown in figure 8 may be attributed to the inability of the bucks to utilized 300 and 400 mg vitamin C to ameliorate high ambient temperature which affects seminiferous tubules arrangement and causes defect in spermatogenesis.

5.27 EFFECT OF INTERACTION BETWEEN BREED AND SEASON ON SPERM MORPHOLOGY OF RABBIT BUCKS

The significant increase of bent tail in crossbred bucks in hot dry season as shown in table 4.28 may be attributed to high ambient temperature which could affect epididymis. The significant increase of double head neck and flagellum in crossbred in the cool wet season may be attributed to high core body and scrotal temperature which could cause atrophy of epididymis thus affecting spermatozoa storage.

5.28 EFFECT OF INTERACTION BETWEEN BREED AND MONTH ON SPERM MORPHOLOGY OF RABBIT BUCKS

The significant increase of proximal cytoplasmic droplet in purebred in the month of August as shown in figure 9 may be attributed to high core body and scrotal temperature which affects epididymis function.

CHAPTER SIX

6.0 SUMMARY, CONCLUSION AND RECOMMENDATION

6.1 Summary

An experiment was conducted to evaluate the effect of dietary levels of vitamin C on growth performance, thermoregulatory response and semen characteristics of rabbit bucks in hot dry and cool wet seasons in sub humid area of Nigeria.

Vitamin C levels had significant effect on growth performance parameters such as feed intake, water intake and right scrotal circumference at 400 mg. Breed had significant effect on growth performance parameters such feed intake, water intake and reaction time. Feed intake was significantly higher at crossbred while purebred had significant higher water intake and longer reaction time. Season had significant effect on growth performance parameters such as feed and water intake, weight gain, left and right scrotal circumference.

Water intake was significantly higher at hot dry season while feed intake, weight gain, left and right scrotal circumference was significantly higher at coo wet season. Month had significant effect on growth performance parameters such as feed intake, water intake, weight gain, left and right scrotal circumference and reaction time. Feed intake was significantly higher in the month of August, water intake was significantly higher in the month of March, and weight gain was significantly higher in the month of July. Left and right scrotal circumference was significantly higher in months of August and September, while reaction time was significantly higher in the month of September.

There was interaction between vitamin C levels and breed on growth performance parameters such as feed and water intake, left and right scrotal circumference. Purebred fed 400 mg vitamin

C had significantly higher feed and water intake, left and right scrotal circumference. Left scrotal circumference was also significantly higher at purebred fed 100 mg vitamin C. There was interaction between vitamin C levels and month on growth performance parameters such as weight gain, water intake and reaction time.

Weight gain was significantly higher in the month of July at 100 and 200 mg vitamin C levels, water intake was significantly higher in the month of March at 400 mg vitamin C level, while reaction time was significantly longer and shorter in the month of March at 100 and 400 mg vitamin C levels respectively. There was interaction between season and breed on growth performance parameters such as left and right scrotal circumference. Left and right scrotal circumference of purebred was significantly larger in cool wet season than crossbred bucks.

Vitamin C levels had significant effect on thermoregulatory parameters such as rectal temperature. Rectal temperature was significantly higher at 100 mg vitamin C. Season had significant effect on thermoregulatory parameters such as skin, ear, scrotal, rectal temperature, respiratory and heart rate. Skin temperature was significantly higher in cool wet than hot dry season, while ear, scrotal, and rectal temperature, as well as respiratory and heart rate were significantly higher in hot dry than cool wet season. Month had significant effect on thermoregulatory parameters such as skin, ear, scrotal and rectal temperature, as well respiratory and heart rate. Skin temperature was significantly higher in the month of September, while ear, scrotal and rectal temperature, as well respiratory and heart rate were significantly higher in the month of March. There was interaction between vitamin C levels and season on thermoregulatory parameters such as respiratory rate. Respiratory rate was significantly higher in 100 mg vitamin C level in the hot dry season. There was interaction between vitamin C levels and breed on

thermoregulatory parameters such as rectal temperature. Rectal temperature was significantly higher at crossbred fed 300 mg vitamin C.

There was interaction between month and vitamin C levels on thermoregulatory parameters such as skin temperature, ear temperature, heart and respiratory rate. Skin temperature was significantly higher in the month of September at 400 mg vitamin C. Ear temperature was significantly higher in the month of March at 100 mg vitamin C heart and respiratory rate were significantly higher in the month of March at 100 mg vitamin C level.

There was interaction between season and breed on thermoregulatory parameters such as rectal temperature. Rectal temperature was significantly higher in purebred in the hot dry season. There was interaction between breed and month on thermoregulatory parameters such as rectal temperature. Rectal temperature was significantly higher in the month of March at purebred.

Vitamin C levels had significant effect on semen characteristics parameters such as live sperm. Live sperm was significantly higher at 400 mg vitamin C. Breed had significant effect on semen characteristics parameters such as live and dead sperm. Live sperm was significantly higher in crossbred than purebred. Season had significant effect on semen characteristics parameters such as semen volume, live sperm and dead sperm. Semen volume and dead sperm were significantly higher at hot dry season. While live sperm was significantly higher at cool wet season.

Month had significant effect on semen characteristics parameters such as semen volume, sperm motility, colour, live sperm and dead sperm. Semen volume and dead sperm were significantly higher in the month of April. Sperm motility was significantly higher in the month of June. Semen colour was significantly higher in the month of July. Live sperm was significantly higher in the month of August. There was interaction between vitamin C levels and season on semen

characteristics parameters such as semen colour. Semen colour was significantly higher at 400 mg vitamin C at hot dry season.

Vitamin C levels had significant effect on sperm morphological abnormalities parameters such as primary (stump tail) and secondary (bent mid piece and double head single neck and flagellum) abnormalities. Stump tail was significantly higher at 100 mg vitamin C, while bent mid piece and double head single neck and flagellum were significantly higher at 300 mg vitamin C. Season had significant effect on sperm morphological abnormalities parameters such as abnormal sperm, primary (tailless head and rudimentary) and secondary (curved mid piece and round cell) abnormalities. Abnormal sperm was significantly higher in hot dry season. Primary (tailless head and rudimentary) abnormalities were significantly higher in hot dry season. Secondary abnormalities (curved mid piece and round cell), curved mid piece was significantly higher in hot dry season. While round cell was significantly higher in cool wet season.

Month had significant effect on primary and secondary abnormalities, primary abnormalities (tailless head, rudimentary tail and narrow head), tailless head and rudimentary tail were significantly higher in the month of March while narrow head was significantly higher in the month of August. Secondary abnormalities such as proximal cytoplasmic droplet and double head neck and flagellum were significantly higher in the month of July. There was interaction between vitamin C levels and breed on sperm morphological abnormalities parameters such as primary (pyriform) and secondary (translocation cytoplasmic droplet) abnormalities. Pyriform and translocation cytoplasmic droplets were significantly higher in crossbred fed 300 mg vitamin C level. There was interaction between vitamin C levels and month on sperm morphological abnormalities parameters such primary (tailless head, pyriform and ruffle acrosome) and

secondary (bent tail and double head neck and flagellum) abnormalities. Tailless head was significantly higher at 400 mg/kg vitamin C in the month of April, ruffle acrosome and pyriform were significantly higher at 300 mg/kg vitamin C in the months of July and August respectively.

There was interaction between season and breed on secondary sperm abnormalities (bent tail and double head neck and flagellum); bent tail was significantly higher at crossbred in the hot dry season while double head neck and flagellum was significantly higher at purebred in the cool wet season. There was interaction between month and breed on secondary abnormality (proximal cytoplasmic droplet). Proximal cytoplasmic droplet was significantly higher at purebred in the month of June.

6.2 Conclusion

From the result of the experiment it could be concluded that dietary vitamin C levels have significant effect on growth performance, thermoregulatory response and semen characteristics of rabbit bucks. Breeds have significant effect on growth performance and semen characteristics of rabbit bucks. Season have significant effect on growth performance, thermoregulatory response, semen characteristics of rabbit bucks.

6.3 Recommendation

Optimum level of vitamin C supplementation in diet for cross bred is 200mg and 400mg for pure breed for better performance, thermoregulation, and semen quality in hot dry and cool wet season.

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