INFLUENCE OF BUCK EXPOSURE, PROGESTAGEN TREATMENT AND SEASON ON REPRODUCTIVE RESPONSES IN GOATS

BY

BOBWEALTH OAKINA OMONTESE

DEPARTMENT OF THERIOGENOLOGY AND PRODUCTION
FACULTY OF VETERINARY MEDICINE
AHMADU BELLO UNIVERSITY, ZARIA, NIGERIA

SEPTEMBER, 2015

INFLUENCE OF BUCK EXPOSURE, PROGESTAGEN TREATMENT AND SEASON ON REPRODUCTIVE RESPONSES IN GOATS

BY

Bobwealth Oakina OMONTESE (DVM 2010, MSc 2012, ABU)

(PhD/VET-MED/40817/2012-2013)

A THESIS SUBMITTED TO THE
SCHOOL OF POSTGRADUATE STUDIES
AHMADU BELLO UNIVERSITY, ZARIA, NIGERIA

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF DOCTOR OF PHILOSOPHY IN THERIOGENOLOGY

DEPARTMENT OF THERIOGENOLOGY AND PRODUCTION
AHMADU BELLO UNIVERSITY, ZARIA
NIGERIA

SEPTEMBER, 2015

DECLARATION

I hereby declare that the work in this thesis, titled **"Influence of Buck Exposure, Progestagen Treatment and Season on Reproductive Responses in Goats"** was carried out by me at the Department of Theriogenology and Production under the supervision of Professors P. I. Rekwot and J. O. Ayo, and Dr A. I. Nwannenna. The information derived from literature has been duly acknowledged in the text and a list of references provided. No part of this thesis has previously been presented for another degree or diploma in this or any other university.

Bobwealth Oakina OMONTESE	_____	_____
(Name of Student)	(Signature)	(Date)

CERTIFICATION

This thesis, titled "**INFLUENCE OF BUCK EXPOSURE, PROGESTAGEN TREATMENT AND SEASON ON REPRODUCTIVE RESPONSES IN GOATS"** meets the regulations governing the award of the degree of Doctor of Philosophy of the Ahmadu Bello University, Zaria, and is approved for its contribution to knowledge and literary presentation.

Professor P. I. Rekwot Chairman, Supervisory Committee	_____ (Signature)	_____ (Date)
Professor J. O. Ayo Member, Supervisory Committee	_____ (Signature)	_____ (Date)
Dr. A. I. Nwannenna Member, Supervisory Committee	_____ (Signature)	_____ (Date)
Dr. A. I. Nwannenna Head of Department	_____ (Signature)	_____ (Date)
Professor K. Bala Dean, School of Postgraduate Studies	_____ (Signature)	_____ (Date)

DEDICATION

To Jesus Christ, my God and Saviour, for His grace and for giving me the privilege to be of service to humanity, especially as a Theriogenologist.

To my parents, Mr. Paul I. Omontese and Mrs. Esther A. Omontese, for their unflinching support, encouragement and prayers.

To my wife, Carmi, for her selfless love, sacrifices and understanding.

To our son, Bobwealth Jr., and our kids unborn, you constantly remind us of the grace of God freely and lavishly given to us.

To all veterinarians, agriculturists and organisations, involved in ensuring a more dynamic and profitable livestock venture.

ACKNOWLEDGMENTS

First and foremost, I would like to thank my Lord and Saviour, Jesus Christ, who is the author of my life, my reason for living, my reservoir of inspiration, my repository of knowledge, my chest of wisdom and the source of my strength. To HIM be all glory, honour, dominion and power, forever, Amen.

I would like to specially thank my mentor and chairman of my supervisory committee, Prof. P. I. Rekwot for his guidance, patience, intellectual and financial support throughout my postgraduate programme. I thank you for your insight and contributions to my development as a Theriogenologist. Many thanks to Professor J. O. Ayo for encouraging me through challenging times during this study and for helping me improve my reading and writing skills. I sincerely appreciate Dr A. I. Nwannenna for her moral, academic and financial support during the course of the study. I thank Professor I. U. Ate for teaching me the principles of diligence to academic work, for guiding me through the conception and design this study, and, for his moral and financial support.

My unreserved appreciation goes to Dr H. J. Makun for providing the progestins (EAZI-BREED™ CIDR, FGA-45® and FGA-30®) used in this research. I thank the herdsmen and herdswomen who facilitated my postgraduate studies. I thank the staff of the Small Ruminant Research Programme, Biotechnology Research Programme and the Artificial Insemination Unit, National Animal Production Research Institute, Ahmadu Bello University, Shika-Zaria, for the cooperation and assistance accorded me during the study. I sincerely thank Professors A.A. Voh (Jr), A. C. Kudi, J. O. Hambolu, F. Abeke, D. Ogwu, A. Z. Hassan, C. I. Njoku, A. K. B. Sackey, K. A. N. Esievo, L. B. Tekdek, I. Ajogi (late)

and B. D. Remi-Adewunmi (late); Drs. G. Kwanashie, J. Kabir, R. A. Mustapha, A. Mohammed, C. A. Awasum, E. O. Abidoye, M. U. Kawu, P. W. Mshelia, S. Danbirni and B. Mohammed for their encouragement during the course of this work.

I cannot forget the help rendered to me by my brothers, S. Ejeh, T. Daudu, J. Egbamushe, O. Osemeke, P. Aplaka, S. Ayo, D. David and Dr. K. Shedrach, especially when I was in need. Thank you for being my friends indeed. Your labour of love is highly appreciated. My sincere gratitude goes to Drs C. Uchendu and E. Ngbede for helping me with the statistical analyses. My sincere appreciation goes to the former Director, National Animal Production Research Institute, Ahmadu Bello University, Shika-Zaria, Prof. J. O. Gefu, for granting me permission to use the Institute's animals and facilities without which this study would have been difficult to achieve.

Finally, I would like to thank my immediate family members (Paul Omontese, Esther Omontese, Adeline Omontese, Csoni Omontese, Deborah Omontese and Emma-Joshua Omontese), colleagues (Drs. P. Bello, P. Amuta, M. Amoto, B. Hamza, C. Ilozue, M. Esuabom, T. Jatau, I. Ieren, B. Egbodo, B. Habibu, A. Kuje and W. Echekwu) and; fellow postgraduate students (Drs. J. Bugau, A. B. Adewuyi, H. J. Magaji, G. I. Opaluwa, G. Magaji, F. Audu, R. Otolorin, R. Mutah, J. Itodo, T. Mohammed, B. Mohammed, B. Tijanni, D, Iliyasu, M. Angani, A. A. Adeyeye and P. Ofemile) for the good times and memories we had together. I truly appreciate their encouragement, prayers and support. To all others who had in one way or the other contributed to this work but were inadvertently omitted from this acknowledgment, I wish them God's blessings. Thank you.

ABSTRACT

Intravaginal progestagens in combination with gonadotrophins have been used to synchronise oestrus in goats. Recently, the use of "biostimulation" in combination with progestagens is advocated because of ethical concerns regarding hormone residues in food products, environmental contamination and decreased fertility of gonadotrophin-treated does. The aim of the study was to evaluate the influence of buck exposure and progestagen treatments on reproductive responses in goats. Six experiments using Red Sokoto (RS) and Sahel (SH) goats were carried out in the dry (November to April) and rainy (May to October) seasons. In experiment one, the influence of continuous exposure to bucks during progestagen treatment and season on oestrus behaviour and fertility of goats was evaluated. The RS does were treated with Controlled Internal Drug Release (CIDR) device with or without continuous exposure to aproned bucks for 14 days in the dry and rainy seasons. Does were bred on standing oestrus. The result showed that the male effect was comparably effective in inducing oestrus in goats during the dry and rainy seasons. Mean oestrus response rare was higher in buck-exposed than non-exposed Red Sokoto does in both the dry (87.5 % vs 52.5 %) and rainy seasons (88.6 % vs 50.0 %). Exposure to buck during CIDR treatment also improved oestrus response and conception rates in RS does. In experiment two, the effect of buck stimulus at the end of progestagen treatment and season on oestrus pattern and fertility of goats was evaluated. The SH does were treated with exogenous progesterone via a CIDR device with or without aproned buck exposure seven days to the end of progestin treatment in the dry and rainy seasons. The SH does were bred on standing oestrus. The results indicated that the male effect was more pronounced in inducing oestrus in SH goats in the rainy season than dry season. Mean oestrus response rate was higher in buck-exposed than non-exposed Sahel does in the dry (57.4 % vs 40.4 %) and rainy (60 % vs 45 %) season. In experiment three, the influence of buck exposure, season and dose of fluorogestone acetate on oestrus behaviour and fertility of goats was evaluated. The RS does received either 30 mg or 45 mg fluorogestone acetate intravaginal pessaries with or without continuous exposure to aproned bucks for 14 days in the dry and rainy seasons. Does were bred on standing oestrus. Oestrus response was higher in the buck exposed than non-exposed RS does in the dry (67.9 % vs 52.5 %) and rainy (80.0 % vs 71.1 %) seasons. It was concluded that dose of progestagens did not significantly affect oestrus

response, time to onset of oestrus, duration of oestrus and mounts per oestrus period. Exposure of does to buck during progestagen treatment enhanced oestrus response and pregnancy rates in Red Sokoto goats. In experiment 4, the influence of male stimulus at the end of progestagen treatment, dose of fluorogestone acetate and season on oestrus and fertility of Sahel goats was evaluated. The SH does were treated with either 30 mg or 45 mg fluorogestone acetate intravaginal sponges with or without limited buck exposure in the dry and rainy seasons. Does were bred on standing oestrus. Oestrus response was higher in the buck-exposed does (70.8 %) than in the non-exposed does (50.0 %). Pregnancy rates were higher in the dry (60.9 %) than in the rainy season (45.8 %). It was concluded that dose of progestagens did not significantly affect oestrus response in Sahel goats. Teasing during progestagen treatment enhanced oestrus response and pregnancy in the goats. The dry season favoured pregnancy rates in Sahel goats than the rainy season. In experiment five, the serum progesterone profiles of RS does treated with different progestagens with or without continuous buck exposure was evaluated. Does received either CIDR devices, 30 mg fluorogestone acetate intravaginal pessaries, 45 mg fluorogestone acetate intravaginal pessaries, with or without continuous exposure to aproned Red Sokoto bucks for 14 days. Serum progesterone levels were similar in the buck-exposed and non-exposed Red Sokoto does across the days of treatment. In experiment six, the serum progesterone profiles of SH does treated with different progestagens with or without limited buck exposure was evaluated. Does received CIDR devices, 30 mg fluorogestone acetate intravaginal pessaries, 45 mg fluorogestone acetate intravaginal pessaries, with or without limited exposure to bucks. Serum progesterone levels were similar in the buck-exposed and non-exposed Sahel does across the days of treatment.

TABLE OF CONTENTS

TITLE PAGE

COVER PAGE……i

TITLE PAGE……ii

DECLARATION……iii

CERTIFICATION……iv

DEDICATION……v

ACKNOWLEDGMENTS……vi

ABSTRACT……viii

TABLE OF CONTENTS……x

LIST OF TABLES……xvi

LIST OF FIGURES……xvii

LIST OF APPENDICES……xx

LIST OF ABBREVIATIONS……xxi

CHAPTER ONE

1.0 INTRODUCTION……1

1.1 Background……1

1.2 Statement of Research Problems……3

1.3 Justification……5

1.4 General Aim……6

1.5 Specific Objectives……6

1.6 Statement of Research Hypothesis……7

CHAPTER TWO

2.0 LITERATURE REVIEW….....8

2.1 Goats……..….....8

2.2 Goat Production in Developing Countries…….....9

2.3 Nigerian Breeds of Goats.....10

2.3.1 The Sahel goat……...…….……...……...11

2.3.2 The Red Sokoto goat.....…….…….…….…....12

2.3.3 The West African Dwarf goat……..…….….13

2.4 Oestrous Cycle in Goats.....14

2.5 Regulation of the Oestrous Cycle in Goats….……..…….…….17

2.6 Oestrus Synchronisation…….…….....23

2.6.1 Prostaglandin $F_{2\alpha}$ ($PGF_{2\alpha}$)-based synchronisation……...…..……25

2.6.2 Progesterone based synchronisation……...26

2.6.2.1 Short term protocol versus long term protocol……..……..30

2.7 The "Male Effect" in Domestic Animals……30

2.7.1 Male factors influencing the response of the female……...……...38

2.7.1.1 Buck Libido/Sexual Behaviour……...39

2.7.1.2 Buck Vocalisation……...40

2.7.1.3 Buck Age and Experience…….……..41

2.7.1.4 Buck Olfactory and Chemical Cues…….……...41

2.7.1.5 Buck Exposure Frequency and Duration……...42

2.7.1.6 Buck Mating Stimuli……...43

2.7.2 Female factors influencing the response to the male.……..44

2.7.2.1 Doe Dominance..…….....45

2.7.2.2 Doe Age, Experience and Temperament……...45

2.7.2.3 Doe Isolation Prior to Teasing……...……...…….....46

2.7.2.4 Doe Nutritional or Reproductive Status…….……46

2.7.2.5 Doe Parity and Maturity……...……..48

2.7.2.6 Doe Hormonal Treatments Prior/During Exposure to Male Stimulus..……..…...48

2.8 The "Female Effect" in Domestic Animals……49

2.9 Influence of Season on Animal Reproduction……51

CHAPTER THREE

3.0 MATERIALS AND METHODS.....56

3.1 Location of Study.....56

3.2 Seasons of the Study Area..……..……..…..57

3.3 Experimental Animals and Herd Management.....57

3.4 Experimental Progestagens/Exogenous Hormones…….....…..…..57

3.5 Experimental Design 58

3.5.1 Experiment 1: Influence of continuous buck exposure during progestagen treatment and season on oestrus behaviour and fertility of Red Sokoto goats……..58

3.5.2 Experiment 2: Effect of limited buck stimulus and season on oestrus behaviour of progesterone-treated Sahel goats……..58

3.5.3 Experiment 3: Influence of continuous buck exposure, season and dose of fluorogestone acetate on oestrus behaviour and fertility of goats…….59

3.5.4 Experiment 4: Influence of male stimulus, dose of fluorogestone acetate and season on oestrus and fertlity responses of Sahel goats…….59

3.5.5 Experiment 5: Serum progesterone levels of Red Sokoto does treated with different progestagens with or without continuous exposure to bucks..……...……60

3.5.6 Experiment 6: Serum progesterone profiles of Sahel does treated with progestagens with or without limited exposure to bucks…….…..60

3.6 Oestrus Detection and Breeding 67

3.7 Sample collection and hormonal assay……...67

3.8 Data Collection and Analyses.....67

CHAPTER FOUR

4.0 RESULTS……..69

4.1 Meteorological Conditions……..……69

4.2 Oestrus Response of Red Sokoto Does Treated With Progestagens and Continuous Buck Exposure in the Dry and Rainy Seasons..…...…….71

4.3 Interval to Onset of Oestrus of Red Sokoto Does Treated With Progestagens and Continuous Buck Exposure in the Dry and Rainy Seasons...75

4.4 Duration of Oestrus of Red Sokoto Does Treated With Progestagens and Continuous Buck Exposure in the Dry and Rainy Seasons..……..…..……77

4.5 Mounts Per Oestrus Period of Red Sokoto Does Treated With Progestagens and Continuous Buck Exposure in the Dry and Rainy Seasons...79

4.6 Conception, Pregnancy and Kidding Rates of Red Sokoto Does treated With Progestagens and Continuous Buck Exposure in the Dry and Rainy Seasons...81

4.7 Oestrus Response of Sahel Does Treated With Progestagens and 7-Day Buck Stimulus in the Dry and Rainy Seasons.....83

4.8 Interval to Onset of Oestrus of Sahel Does Treated With Progestagens and 7-Day Buck Exposure in the Dry and Rainy Seasons.....87

4.9 Duration of Oestrus of Sahel Does Treated With Progestagens and Exposed to Buck in the Dry and Rainy Seasons…….……...89

4.10 Mounts Per Oestrus Period of Sahel Does Treated With Progestagens and Buck Exposure in the Dry and Rainy Seasons……..….91

4.11 Conception, Pregnancy and Kidding Rates of Sahel Does Treated With Progestagens and Exposed to Buck in the Dry And Rainy Seasons……...……..93

4.12 Oestrus Response of Red Sokoto Does Treated With Progestagens and Continuous Buck Exposure in the Dry and Rainy Seasons..……..…95

4.13 Interval to Onset of Oestrus of Red Sokoto Does Treated With Progestagens and Continuous Buck Exposure in the Dry and Rainy Seasons...99

4.14 Duration of Oestrus of Red Sokoto Does Treated With Progestagens and Continuous Buck Exposure in the Dry and Rainy Seasons..……...101

4.15 Mounts Per Oestrus Period of Red Sokoto Does Treated With Progestagens and Continuous Buck Exposure in the Dry and Rainy Seasons……...103

4.16 Conception, Pregnancy and Kidding Rates of Red Sokoto Does Treated With Progestagens and Continuous Buck Exposure in the Dry and Rainy Seasons……...……105

4.17 Oestrus Response of Sahel Does Treated With Progestagens and Buck Exposure in the Dry and Rainy Seasons……..……..107

4.18 Interval to Onset of Oestrus of Sahel Does Treated With Different Doses of Fluorogestone Acetate and Buck Exposure in the Dry and Rainy Seasons……...111

4.19 Duration of Oestrus of Sahel Does Treated With Different Doses of Fluorogestone Acetate and Buck Exposure in the Dry and Rainy Season …...113

4.20 Mounts Per Oestrus Period of Sahel Does Treated With Fluorogestone Acetate and Buck Exposure in the Dry and Rainy Seasons…..115

4.21 Conception, Pregnancy and Kidding Rates of Sahel Does Treated With Fluorogestone Acetate and Buck Exposure in the Dry and Rainy Seasons.….117

4.22 Serum Progesterone Levels in Red Sokoto Does Treated With Different Progestagens With or Without Continuous Exposure to Bucks….……...119

4.23 Serum Progesterone Levels in Sahel Does Treated With Different Progestagens With or Without Limited Exposure to Bucks…….……..121

CHAPTER FIVE

5.0 DISCUSSION……..123

CHAPTER SIX

6.0 SUMMARY, CONCLUSION AND RECOMMENDATION….……134

6.1 Summary……..……...134

6.2 Conclusion……...……135

6.3 Recommendation.....136

REFERENCES…….……..137

APPENDICES..…….…….…….....177

LIST OF TABLES

TABLE TITLE PAGE

2.1 Hormonal regulation of the reproductive cycle in the female……..……..20

4.1 Meteorological conditions during the dry and rainy seasons of November 2012 to October 2013 in Zaria……..……70

4.2 Oestrus response of Red Sokoto does treated with progestagens and continuous buck exposure in the dry and rainy seasons..……72

4.3 Interval to onset of oestrus of Red Sokoto does treated with progestagens and continuous buck exposure in the dry and rainy seasons..…….....…...76

4.4 Duration of oestrus in Red Sokoto does treated with progestagens and continuous buck exposure in the dry and rainy seasons..……..…..78

4.5 Mounts per oestrus period of Red Sokoto does treated with progestagens and continuous buck exposure in the dry and rainy seasons..…….....80

4.6 Conception, kidding rates and litter size of Red Sokoto does treated with progestagens and continuous buck exposure in the dry and rainy seasons….....82

4.7 Oestrus response of Sahel does treated with progestagens and continuous buck exposure in the dry and rainy seasons..……....84

4.8 Interval to onset of oestrus of Sahel does treated with progestagens and continuous buck exposure in the dry and rainy seasons..…….....…..88

4.9 Duration of oestrus in Sahel does treated with progestagens and continuous buck exposure in the dry and rainy seasons..……90

4.10 Mounts per oestrus period of Sahel does treated with progestagens and continuous buck exposure in the dry and rainy seasons..…….....92

TABLE TITLE PAGE

4.11 Conception, kidding rates and litter size of Sahel does treated with progestagens and continuous buck exposure in the dry and rainy seasons.....94

4.12 Oestrus response of Red Sokoto does treated with progestagens and continuous buck exposure in the dry and rainy seasons..……96

4.13 Interval to onset of oestrus of Red Sokoto does treated with progestagens and continuous buck exposure in the dry and rainy seasons..…….....100

4.14 Duration of oestrus in Red Sokoto does treated with progestagens and continuous buck exposure in the dry and rainy seasons..……..102

4.15 Mounts per oestrus period of Red Sokoto does treated with progestagens and continuous buck exposure in the dry and rainy seasons..…….....104

4.16 Conception, kidding rates and litter size of Red Sokoto does treated with progestagens and continuous buck exposure in the dry and rainy seasons.....106

4.17 Oestrus response of Sahel does treated with progestagens and continuous buck exposure in the dry and rainy seasons..……..108

4.18 Interval to onset of oestrus of Sahel does treated with progestagens and continuous buck exposure in the dry and rainy seasons..…….....112

4.19 Duration of oestrus in Sahel does treated with progestagens and continuous buck exposure in the dry and rainy seasons..……..114

4.20 Mounts per oestrus period of Sahel does treated with progestagens and continuous buck exposure in the dry and rainy seasons..…….....116

4.21 Conception, kidding rates and litter size of Sahel does treated with progestagens and continuous buck exposure in the dry and rainy seasons….....118

LIST OF FIGURES

FIGURE TITLE PAGE

2.1 Endocrine control of reproduction in the female……..……..21

2.2 Schematic representation of the different physiological events occurring during the oestrus cycle in goats: Pattern of follicle development.……..……..…….22

3.1 Treatment protocol summary for oestrus synchronisation in Red Sokoto

does using Controlled Internal Drug Release Devices and exposure to aproned bucks…….61

3.2 Treatment protocol summary for oestrus synchronisation in Sahel does using Controlled Internal Drug Release Devices and exposure to aproned bucks……..……...62

3.3 Treatment protocol summary for oestrus synchronisation in Red Sokoto does using Fluorogestone Acetate pessaries (30 mg and 45 mg) and exposure to aproned bucks…….....63

3.4 Treatment protocol summary for oestrus synchronisation in Sahel does using Fluorogestone Acetate pessaries (30 mg and 45 mg) and exposure to aproned bucks……..…....64

3.5 Blood sampling summary to evaluate serum progesterone profile of Sahel does treated with Controlled Internal Drug Release Devices, Fluorogestone Acetate pessaries (30mg and 45mg) with or without aproned buck exposure.……..…...65

3.6 Blood sampling summary to evaluate serum progesterone profile of Sahel does treated with CIDR®, FGA-30® and FGA-45® with or without aproned buck exposure…….……..…66

4.1 Cumulative frequency of oestrus observed over a 19-day period

in Red Sokoto does treated with Controlled Internal Drug Release Devices and continuous buck exposure in the dry and rainy season…….....73

FIGURE TITLE PAGE

4.2 Period of oestrus occurrence observed over a 19-day period in Red Sokoto does treated with Controlled Internal Drug Release Devices and continuous buck exposure in the dry and rainy season……74

4.3 Cumulative frequency of oestrus observed over a 19-day period in Sahel does treated with Controlled Internal Drug Release Devices and buck exposure in the dry and rainy season…….....85

4.4 Period of oestrus occurrence observed over a 19-day period in Sahel does does treated with Controlled Internal Drug Release Devices and buck exposure in the dry and rainy season…….....86

4.5 Cumulative frequency of oestrus observed over a 19-day period in Red Sokoto does treated with Fluorogestone Acetate pessaries (30 mg and 45 mg) and continuous buck exposure in the dry and rainy seasons.....97

4.6 Period of oestrus occurrence observed over a 19-day period in Red Sokoto does treated with Fluorogestone Acetate pessaries (30 mg and 45 mg) and continuous buck exposure in the dry and rainy seasons..……..…….....98

4.7 Cumulative frequency of oestrus observed over a 19-day period in Sahel does treated with Fluorogestone Acetate pessaries (30 mg and 45 mg) and buck exposure in the dry and rainy seasons..…….…….....109

4.8 Period of oestrus occurrence observed over a 19-day period in Sahel does does treated with Fluorogestone Acetate pessaries (30mg and 45mg) and buck exposure in the dry and rainy seasons...……...110

4.9 Mean progesterone concentrations of Red Sokoto does during treatment with Controlled Internal Drug Release Devices, Fluorogestone Acetate pessaries (30mg and 45mg) with or without buck exposure……...…120

4.10 Mean progesterone concentrations of Sahel does during treatment with Controlled Internal Drug Release Devices, Fluorogestone Acetate pessaries (30mg and 45mg) with or without buck exposure……..….122

LIST OF APPENDICES

APPENDIX TITLE PAGE

1 Distribution of Sahel goats in Nigeria……..……...……..…..177

2 Distribution of Red Sokoto goats in Nigeria…….....178

3 ELISA procedure for determination of serum progesterone concentration……..…..179

LIST OF ABBREVIATIONS

AI	Artificial Insemination
BCS	Body Condition Score
BE	Buck Effect/Exposure
CIDR	Controlled-Internal Drug Release
CL	*Corpus luteum*
CN	Control
COO	Cessation of Oestrus
CR	Conception Rate
d	Day
DOO	Duration of Oestrus
DS	Dry Season
ELISA	Enzyme-Linked Immunosorbent Assay
FGA	Fluorogestone Acetate
FSH	Follicle-Stimulating Hormone
GL	Gestation Length
GnRH	Gonadotropin-Releasing Hormone
i.m.	Intramuscular
Kg	kilogram
KR	Kidding Rate
LH	Luteinising Hormone
MGA	Melengestrol acetate
ml.	Millilitres

MPOP	Mounts per Oestrus Period
n	Number
NAPRI	National Animal Production Research Institute
ng	Nanogram
O17β	Oestradiol 17β
ORR	Oestrus Response Rate
P_4	Progesterone
$PGF_{2\alpha}$	Prostaglandin $F_{2\alpha}$
PMSG	Pregnant Mare Serum Gonadotropin
PR	Pregnancy Rate
PRID	Progesterone-Releasing Intravaginal Device
RIA	Radioimmunoassay
RS	Rainy Season
RSG	Red Sokoto Goat
SEM	Standard Error of the Mean
SHG	Sahel Goat
TOO	Time to Onset of Oestrus

CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND

The demand for food to feed the world's growing population has necessitated a higher demand for animal products such as meat, eggs and milk (FAO, 2013). Goats provide food for the growing population in the form of meat and milk, while goat skin and hair serve as raw materials in the clothing and leather industries (Morand-Fehr *et al.,* 2004; Ajala, 2004; Boyazoglu *et al.,* 2005). In Nigeria, goats play a very important role in the economy of rural dwellers, especially the women folk (Ajala, 2004; Odeyinka and Okunade, 2005). The potential importance of goat meat in meeting the protein requirement of Nigeria has been reported (Akusu, 2003; Ozung *et al.,* 2011). The demand for meat from goat production may be met on a sustainable basis in Nigeria through intensive goat production, involving estrus synchronisation, which facilitates strategic breeding techniques for twice yearly kidding and feed-lot fattening of kids (Kawu, 2000). Several methods of oestrus induction in goats have been described (Abecia *et al.,* 2012). There are hormonal (use of prostaglandins, progestagens, gonadotrophin, melatonin) and non-hormonal methods such as photoperiod control, flushing, buck introduction to stimulate reproductive cyclicity/buck effect (Mellado *et al.,* 2000; Delgadillo *et al.,* 2006, 2009). Although the hormonal methods are more effective, they are more expensive while the non-hormonal methods, though less effective, are cheaper and easy to apply in practice (Delgadillo *et al.,* 2009; Ungerfeld, 2011). Non-hormonal methods are alternatives to the conventional methods of oestrus synchronisation (Martin *et al.,* 2004a; Delgadillo *et al.,* 2009). The most popular non-

hormonal methods include the 'male effect' and flushing (Rosa and Bryant, 2002; Keskin, 2003; Ungerfeld *et al*., 2003; Ungerfeld, 2005; Gelez and Fabre-Nys, 2004, 2006; Delgadillo *et al.*, 2011a; van Rooyen, 2013).

Biostimulation is the stimulatory effect of a male on oestrus and ovulation through the genital or pheromonal stimulation, or other less well-defined external cues (Rekwot *et al.*, 2000a; 2001; 2004). In domestic animals and humans, priming pheromones from the male have an influence on the induction of puberty (Rekwot *et al*., 2000a; Nishimura *et al.*, 2005), oestrus (Mellado *et al.*, 2000; Chemineau *et al.*, 2006), ovulation (Delgadillo *et al.*, 2011b; Ungerfeld, 2011; van Rooyen, 2013), sexual attraction (Grammer *et al.*, 2005; Reolofs *et al*., 2008), sexual territoriality (Wyatt, 2009), termination of seasonal anoestrus and shortening of postpartum anoestrus (Rekwot *et al.*, 2001; 2004; Berardinelli *et al.*, 2005; Landaeta-Hernandez *et al.*, 2006; Delgadillo *et al.*, 2015). The 'male effect' has long been known in goats (Hawken *et al.*, 2005; Delgadillo *et al*., 2009; Simoes, 2015) and sheep (Rosa and Bryant, 2002; Martin *et al.*, 2004a,b; Ungerfeld *et al*., 2004). The response of females exposed to the male effect involves an increase in luteinizing hormone (LH) pulse frequency that ends with an LH surge, similar to that observed during the follicular phase of a normal oestrous cycle, which is followed by ovulation (Ungerfeld, 2007; Hawken *et al*., 2008; Hawken and Martin, 2012). The LH promotes follicular development and oestradiol production (Endo and Tanaka, 2015).

The sudden introduction of males to a herd of anoestrus females induces the onset of reproductive activity in cattle (Rekwot *et al*., 2001; Ungerfeld, 2009; Fiol *et al.*, 2010),

sheep (Ungerfeld *et al.,* 2002, 2004; Yildiz *et al.,* 2003; Hawken *et al.,* 2007; Hawken and Beard, 2009; Ungerfeld, 2011) and goats (Veliz *et al.,* 2006; Alvarez *et al.,* 2009; Delgadillo *et al.,* 2011b; Zarazaga *et al.,* 2011; Celi *et al.,* 2013). Using the 'male effect' for oestrus synchronisation is more economical than exogenous hormone administration and is recommended in extensive production when animals are cycling (Keskin, 2003). The vocalisation emitted by sexually active males stimulates oestrus behaviour and LH pulsatility in anoestrus does. However, it is also known that pheromonal emission alongside other sensory cues is greatly influenced by season (Avdi *et al.,* 2004; Lopez-Sebastian *et al.,* 2007; Hawken *et al.,* 2009; Zarazaga *et al.,* 2011).

1.2 STATEMENT OF RESEARCH PROBLEMS

There is a growing concern all over the world on the use of exogenous hormones in animal production due to drug residues in animal products (van Rooyen, 2013). The use of progestagens plus equine chorionic gonadotrophin (eCG), which mimics the hormonal pattern of a normal oestrous cycle is effective for obtaining a high percentage of does in oestrus (Mellado *et al.,* 2000; Delgadillo *et al.,* 2011a; Ungerfeld, 2011; Omontese *et al.,* 2012). However, this technique is far from being cost effective under local market conditions, especially in a developing country like Nigeria.

A variety of oestrus synchronisation regimes for cattle, sheep and goats indicate that the administration of pregnant mare serum gonadotrophin (PMSG), human chorionic gonadotrophin (hCG), follicle-stimulating hormone (FSH) or gonadotrophin-releasing hormone (GnRH) enhances the ovulatory response of progestagen or prostaglandin-treated

animals (Dare *et al.,* 2010; Abecia *et al.,* 2012; Omontese *et al.,* 2012; 2013a; 2013b). This is particularly important because sufficient gonadotrophins must be available to initiate the preovulatory events. However, the use of gonadotrophins increases the cost of the synchronisation scheme and occasionally reduces fertility in does repeatedly treated with eCG consequent upon immune responses against this hormone (Drion *et al.,* 2001; Maurel *et al.,* 2003; Herve *et al.,* 2004; Viudes *et al*., 2007). The eCG treatment may cause "unwanted superovulation", resulting in ewe mortalities and reduced viability of lambs (Maurel *et al.,* 2003; van Rooyen, 2013). Furthermore, multiple injections of GnRH (Holtz *et al.,* 2008) or FSH (Lehloenya *et al.,* 2008) are required to obtain a preovulatory LH peak in progestagen-treated animals.

In sheep and cattle, teasing during or after progestagen treatment increases the number of ewes and cows in oestrus (Hawken *et al*, 2005; Hawken and Beard, 2009), improves conception rate (Lassoued *et al.,* 2009; Fabry Nys, 2013; van Rooyen, 2013) and reduces lambing interval (Morales-Terán *et al.,* 2011). Similarly, Ungerfeld *et al.* (2003) reported concentrated oestrus following medroxyprogesterone priming in ewes exposed to rams during the non-breeding season. In another study, the onset of oestrus was advanced in ewes treated with prostaglandin during the breeding season by the introduction of rams (Ungerfeld, 2011). Consequently, it is conceivable that the introduction of bucks during progestagen treatment may enhance oestrus response and reproductive performance of goats. In the tropics and specifically Nigeria, such studies in goats are scanty.

The effect of various progestagens (EAZI-Breed Controlled Internal Drug Release devices (CIDR®) Fluorogestone Acetate intravaginal pessaries (FGA-30® mg and FGA-40® mg) alone and in combination with eCG has been evaluated in Red Sokoto (RS) and Sahel (SH) goats (Omontese, 2009; 2012), but there is a paucity of information on the influence of buck exposure or teasing during progestagen treatment in both RS and SH goats.

1.3 JUSTIFICATION OF THE STUDY

The RS and SH goats are the most widespread breeds of goats in Northern Nigeria. Information on effective, cheap and "easy to apply" oestrus synchronisation protocols using the buck effect and progestagens will enable farmers to improve the reproductive efficiency of their flocks. Since the 'male effect' stimulates an increase in LH pulsatility (Ungerfeld *et al.*, 2004), it is possible that buck exposure will improve oestrus response and reproductive performance of progestagen-treated does.

The introduction of males causes expression of oestrus behaviour in progestagen-treated ewes and does. This expression of oestrus behaviour may occur through a greater follicular growth rate and estrogen secretion, caused by an increasing LH pulse frequency similar to the activity of eCG, thereby reducing the possibilities for silent oestrus (Mellado *et al.*, 2000; Ungerfeld *et al.*, 2004; Hawken *et al.*, 2007; Delgadillo *et al.*, 2011b). Consequently, the cost of acquiring exogenous gonadotrophin may be channeled into other aspects of production such as feeding and improving livestock husbandry practices.

Reduced fertility rates have been reported following repeated administration of exogenous gonadotrophin due to an immune response against the hormone (Maurel *et al.,* 2003; Herve *et al.,* 2004). Therefore, the substitution of exogenous gonadotrophin with "buck effect' following progestagen treatment may play complementary roles in ensuring the availability of adequate amounts of LH required to initiate preovulatory events.

Importantly, this research will evaluate newer approaches to the use of 'biostimulation' involving stimulatory effects induced by the presence of a male on reproductive characteristics of females; for example, the onset of puberty, oestrus expression and ovulation induction. This non-hormonal approach could help minimise the use of exogenous hormones in improving productivity of sheep and goats; hence, reducing cost of drugs and also the exposure of humans to meat and milk containing hormone residues with its attendant health hazards.

1.4 GENERAL AIM OF THE STUDY

The aim of this study was to investigate the influence of 'buck exposure' on oestrus response and fertility of progestagen-treated RS and SH does.

1.5 SPECIFIC OBJECTIVES OF THE STUDY

The specific objectives of this study were to evaluate the;

1. Influence of 'buck exposure' (male effect) on oestrus response, conception and kidding rates of progestagen-treated RS and SH goats.

2. Influence of ‘buck exposure’ (male effect) and dose of progestagen on oestrus response, conception and kidding rates of RS and SH goats.

3. Influence of ‘buck exposure’ (male effect) on serum progesterone (P_4) profiles of RS and SH goats following treatment with different progestagen types; (EAZI-Breed Controlled Internal Drug Release [CIDR®] devices and Fluorogestone Acetate intravaginal pessaries [FGA-30 mg® and FGA-45 mg®]).

1.6 STATEMENT OF RESEARCH HYPOTHESIS

Null hypothesis (Ho): Buck exposure does not affect oestrus response and fertility rates of progestagen-treated RS and SH goats.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 GOATS

Goats are one of the oldest domesticated animal species (Boyazoglu *et al.*, 2005; Galal, 2005). They are renowned for their hardiness and can survive in most environments (Boyazoglu *et al.*, 2005). For thousands of years, goats have been reared for milk, meat, hairs and hides (Morand-Fehr *et al.*, 2004; Boyazoglu *et al.*, 2005). Goat population has increased worldwide during the last three decades and is presently estimated at approximately 840 million heads (Simela and Merkel, 2008). With an increase in demand by consumers for low-fat red meat alternatives, the future of the goat meat industry looks promising (Dhanda *et al.*, 2003). Despite the fact that goats can be intensively managed with high inputs for specialty markets, goat production occurs predominantly in developing countries to provide meat and milk for a family's consumption (Morand-Fehr *et al*., 2004; Olivier *et al.*, 2005). Therefore, goat production is primarily associated with poverty reduction strategies and has been neglected in development plans of many countries (Dubeuf *et al.*, 2004). In developing countries, people suffer from malnutrition, since food is scarce or unbalanced in terms of nutrients. Addressing this situation requires that alternatives in terms of sources of animal protein are investigated and goats are potent sources of protein (Greyling *et al.*, 2004). Goat meat on average consists of 72.3 % moisture, 21.0 % protein, 4.7 % fat and 1.1 % ash per 100 g of fresh meat (Dhanda, 2001). Studies comparing sheep and goat meat based on their protein contents have revealed that chevon is not inferior to mutton (Hoffman *et al.*, 2002).

Goats rank high after cattle in the production of meat, milk and hides in the tropics (Boyazoglu and Morand-Fehr, 2001; Dhanda *et al.,* 2003). Besides, they rank second in income generation after cattle and remain preferred to other kinds of meat (Otuma, 2006). Short gestation period and high fecundity rate make them distinct for selection as a good source of animal protein and income generation for poor rural farmers (Dubeuf *et al.,* 2004; Galal, 2005). Goat populations have been described as comprising three main types; namely, fibre goats (e.g., Angora, Cashmere), dairy goats (e.g., Saanen, Toggenburg, Nubian) and meat goats (e.g., Boer, Spanish) (Dhanda *et al*., 2003).

2.2 GOAT PRODUCTION IN DEVELOPING COUNTRIES

The bulk of the world's goat population is found in south-east Asia and Africa, where goats are the major source of meat. Unfortunately, lack of an organized goat meat industry and marketing structure in developing countries is primarily responsible for their poor export earnings compared to those in developed countries such as Australia and New Zealand (Dhanda *et al.,* 2003). Most developing countries are located in the tropics and subtropics (Greyling *et al*., 2004; Boyazoglu *et al.,* 2005). The per capita income in these countries is low as compared to developed nations (Olivier *et al.,* 2005). Similarly, the dietary intake of carbohydrate and, especially, protein of individuals in developing countries is also low. Countries in Africa and south-east Asia have the lowest animal protein and goats are the major source of meat production intake compared to developed countries where goats are considered as specialty or exotic livestock (FAO, 2003). Approximately 79 % of the world's populations of goats are distributed amongst less-developed countries (Galal, 2005; Olivier *et al.,* 2005).

Goats play a significant role in the food chain and overall livelihoods of rural households, where they are largely the property of women and their children (Lebbie, 2004). In developing countries, goats are chiefly raised for meat products, although they also possess dairy potential as one of their main attributes (Olivier *et al.,* 2005). It is difficult to quantify goat milk consumption in developing countries because it is not widely sold, but instead is locally consumed (Dubeuf *et al.,* 2004). Vitamin A level in goat milk is almost twice that of cow milk. Goat milk has higher medicinal value than cow milk, high vitamin B content and high digestibility, which makes it helpful in relieving stress and constipation. In addition, the fats in goat milk are easily digested, because of their smaller fat globules (James *et al*., 2005). The demand for goat meat surpasses supply in most less-developed countries, which in turn raises the unit price sold for goat compared to mutton (Devendra, 2001). Rural households own greater than 90 % of the goat population in less developed countries (Boyazoglu *et al.,* 2005).

2.3 NIGERIAN BREEDS OF GOAT

The estimated population of goats in Nigeria is 54.5 million (FAOSTAT, 2009). The Nigerian goat population is the largest in Africa and the fourth largest in the world after India, China and Pakistan (Devendra, 2001; FAOSTAT, 2009). The vast majority of the small ruminant are found in the northern parts of Nigeria (Zahradeen *et al,* 2008; Ozung *et al.*, 2011). Goats contribute about 24 % of the Nigerian meat supply (Otuma, 2006). Three main varieties and crosses of goats are recognised in Nigeria; the Sahel, Desert or West African long-legged goat, the Red Sokoto and the West African Dwarf (WAD) goat (Ngere

et al., 1984; Odo, 2003; Zahradeen *et al.,* 2007, 2008; Okonkwo *et al*., 2011; Ozung *et al.,* 2011). Goat rearing has increased over the past 30 years in Nigeria (Otuma, 2006).

2.3.1 The Sahel or Desert Goat

The Sahel goat is found along the northern borders of Nigeria (Maina *et al.,* 2006; Igbokwe *et al.,* 2009). It is generally the goat variety preferred by pastoralists because of their adaptability to the semi-arid and arid regions, their ability to withstand drought condition, their prolificacy and hardiness (Otuma and Osakwe, 2008). It is the least populous goat breed in Nigeria (Zahradeen *et al*., 2008). The coat colour is often white or dappled, the ears are pendulous and the legs are notably longer than other breeds of goats in the country. Sahel goats are found in the semi-arid zones of the Northern parts of the country (Zahradeen *et al.,* 2008; Waziri *et al.,* 2010). They are long-legged with good adaptation to this arid environment (Igbokwe *et al*., 2009). The Borno white ecotypes are recognized by their physical appearance and performance (Kwari *et al.,* 2004). Oestrus duration of 42-43 hours and time to onset of oestrus of 37 hours have been reported following oestrus synchronisation in Sahel goats using prostaglandins (Omontese *et al.,* 2013a).

Age at first kidding is reported at 13 months (Wilson, 1991). Weight at birth is reported to range from 1.10 ± 0.22 kg to 1.5 ± 0.19 kg in the dry and rainy seasons, respectively, while males display significant superior birth weight than females (Otuma and Osakwe, 2008). Sahel goats breed all year round and reach live weights of about 16 kg to 20 kg at 18 months of age (Otuma and Osakwe, 2008). Age of the Sahel buck is a major determinant of the semen quality in the humid zone of Nigeria (Oyeyemi *et al.,* 2011). The multi-coloured Sahel breed of goat is known for its good meat quality, but poorer meat yield, compared to

the RS goat (Pagot, 1993). It is also reported to produce the highest milk yield under semi-intensive management system in the Savannah zone of Nigeria compared to RS and West African Dwarf breed of goats (James *et al.,* 2005; Zahraddeen *et al*., 2008).

2.3.2 The Red Sokoto Goat

The RS (Kano Brown, Savannah Brown or Maradi) goat is probably the most widespread and well-known type in Nigeria (Ngere *et al.,* 1984; Zahradeen *et al.,* 2007, 2008; Ozung *et al*., 2011) and consists of about 60 % of the Nigerian goat population (FAOSTAT, 2009). It is found in the Northern Guinea Savannah zone of Nigeria (Daudu, 1984; Okonkwo *et al.,* 2011). It is the usual village goat in the northern two-thirds of Nigeria although it is less common with trans-human pastoralists (Midau *et al.,* 2010). RS goats are year-round breeders with age and weight at first oestrus ranging from 120 – 157 days and 10 – 18 kg, respectively (Wilson, 1991). Oestrous cycle length and oestrus duration of the RS goat ranges from 19-21 days and 19-26 hours, respectively (Wilson, 1991; Pathiraja *et al.,* 1991; Fasanya *et al*., 1992a). Completion of uterine involution and first post-partum oestrus occur between 24-28 days and 19-30 days, respectively (Fasanya *et al.,* 1992b; Kawu *et al.,* 2003). The total testis and epididymis weights of adult RS goats represents 0.56 % of body weight at 2–2.5 years' old (Daudu, 1984).

It is suggested that populations of the RS goats are spread across the southern and eastern parts of Northern Nigeria from Sokoto through the Savanna belts, giving rise to the Kano Brown and, further east, to the Sahel types of Borno State (Wilson, 1991). The breed is a good meat animal and it weighs about 1.5-2.0 kg at birth and reaches about 12.0 kg, when

weaned at 3 months under good management (Adeyinka and Mohammed, 2006). The RS goat is the source of 'Morocco leather' known in Europe from the medieval period onwards and it acquired its name because it was transported across the Sahara by caravans controlled by Moroccan merchants (RIRDC, 2003). The skin of the RS goat is known for its suitability for fine leather, which commands premium in the international market (Akusu, 2003; RIRDC, 2003). In addition, more than any other species of ruminants, goats serve as an alternative investment readily converted to cash to meet crucial financial needs of members of rural communities (Chentouf *et al.,* 2011; Otaru *et al.,* 2011). The breed is highly prolific and widely distributed in Nigeria (Otuma and Osakwe, 2008).

2.3.3 The West African Dwarf Goat

The WAD is found in the humid forest belts of Nigeria. West African Dwarf goats reared traditionally have proven to be fertile and prolific, and these attributes may, however, be negated by constraints such as disease, nutrition and poor management (Faye *et al.,* 2004; Otaru *et al.,* 2011). Although WAD goat is found in 'many local types', no published account differentiates them. WAD goats are stereotypically said to be native to the forest belts, but their presence in Borno State and in adjacent Republics of Cameroon and Chad suggests that they were far more widespread until recently. The WAD goat corresponds to the West African Grassland Dwarf, described for Cameroon by Ndamukong *et al*. (1989). They usually appear in white, brown and black coat colours with prolificacy and fecundity rates highly affected by coat colour types (Ebozoje and Ikeobi, 1998).

The WAD goat originally evolved from a long-legged type, probably ancestral to today's Sahel goat (Epstein and Mason, 1971). The WAD is usually black, although patched, pied,

and occasionally all-white animals can be seen, even on the coast (Epstein and Mason, 1971). Chang and Landauer (1950) argued that the WAD is a proportionate dwarf, but Epstein and Mason (1971) reported that the distorted forms and extremely short legs do suggest achondroplasy. Physiological experiments have shown that the WAD goat is not particularly adapted to high ambient temperatures although it is trypanotolerant because the breed thrives in tsetse areas in Nigeria (Leigh and Ajibade, 2010).

The mean oestrous cycle lengths and oestrus duration of WAD does has been reported to be 19.4 ± 1.7 d and 33.3 ± 6.6 h, respectively (Akusu, 2003). Progesterone levels are minimal (0.18 ± 0.04 ng/ml) on the day of oestrus, reach a mean level of 3.45 ± 0.12 and 0.74 ng/ml during pregnancy and parturition, respectively. Postpartum progesterone levels in WAD goats are generally lower than 1 ng/ml (Akusu, 2003). Kidding intervals in the WAD goat is 261 ± 75 days, with an average litter size of 1.6 ± 0.5. Annual reproductive rate is 2.3 kids per doe, and is influenced by age of dam, month and year of parturition (Adeoye, 1985). The WAD goats, apparently, perform better during the dry period when they are virtually free from diseases/parasites and can make use of crop by-products or feed resources by browsing (Adeoye, 1985). Osinowo (1990) reported that the WAD goats in their natural habitat are about 50 cm in height and 20 kg in weight, but tend to be larger as they approach the Savannah zone of Nigeria.

2.4 OESTROUS CYCLE IN GOATS

Oestrus is the time at which the female is receptive to the male and stands to be mated, while the period of time between two oestrus events is defined as the oestrous cycle (Thompson *et*

al., 2004; Fatet *at al.,* 2011). The length of the estrous cycle in goats ranges from 19 to 21 days in most of the breeds (Greyling, 2000; Wildeus, 2008, 2010) although the pygmy goat has an estrous cycle length of 24 days (Jarosz *et al.,* 1971). Generally, the oestrous cycle is divided into four major stages viz; proestrus, oestrus, metoestrus and dioestrus, and, each stage is characterized by a predominant hormone which usually affects the animal behaviour. Measurements of intravaginal impedance can be useful to monitor the oestrous cycle in goats (Blaszczyk *et al.,* 2013). Oestrus behaviour is influenced by age (Song *et al*., 2006), presence of the male (Romano, 2001, 2002; Rivas-Munoz *et al.,* 2007; Lopez-Sebastian *et al.,* 2007), hormone treatments (Omontese *et al*., 2012, 2013a; Kaya *et al*., 2013; Christensen *et al*., 2014), season (Pierson *et al.,* 2003; Chemineau *et al.,* 2008; Lehloenya *et al.,* 2008) and breed (Hashemi *et al.,* 2006; Moeini *et al.,* 2007). Oestrus duration ranges between 21 to 26 hours in RS goats (Osinowo, 1990; Wilson, 1991; Pathiraja *et al.,* 1991; Fasanya *et al.,* 1992a), 22 hours in Angora goats (van Rensburg, 1971), 37 hours in the Boer goat (Greyling, 2000) and 96 hours in pygmy goats (Jarosz *et al.,* 1971). The most commonly stated oestrus length is 36 to 37 h (Greyling, 2000; Fatet *et al.,* 2011).

Goats have one to four ovarian follicular waves during the estrous cycle, with four waves being the most common (Menchaca and Rubianes 2002; Medan *et al.,* 2003a, 2005; Fatet *et al.,* 2011). A follicular wave is defined by sequential days of entry of follicles ≥ 6 mm into the active pool, and the emergence day is defined as the first day that the ≥ 6 mm follicles were 3 mm (Medan *et al.,* 2003a). Only the first and the fourth waves have evident follicular dominance, while follicles from the first wave and the ovulatory (fourth) wave reach larger

diameters and have greater tenacity, compared to the second and third waves (Menchaca and Rubianes, 2002; Fatet *at al.,* 2011). Ginther and Kot (1994) reported that the fourth wave emerged on average, on day 13 of the cycle and the inter-wave intervals (days) were longer for waves 1 and 4, compared to those for waves 2 and 3. The interval between the end of oestrus synchronisation treatment (removal of sponge or administration of prostaglandin) and onset of oestrus is affected by the ovarian follicular dynamics (Fonseca *et al.,* 2005, Wildeus, 2008). The time of ovulation in goats vary between breeds with a wide range between 24 to 103 hours (Menchaca and Rubianes, 2001; Fatet *et al.,* 2011). Greyling (2000) reported a value of 36.8 hours after the onset of oestrus in the Boer goat doe.

The pre-ovulatory luteinising hormone (LH) peak is reported to occur 8 to 11.6 hours after the onset of oestrus (Greyling, 2000), while the *corpus luteum* (CL) is found to reach its maximum diameter between days 8 and 14 of the cycle (Castro *et al.,* 1999). Early CL lysis, occurring within the first 5 to 6 days of the estrous cycle, is reported to create a tight and synchronised period of ovulations with a shorter interval between lysis and ovulation when compared with the CL lysis. CL lysis occurs at a more advanced luteal stage of between day 11 to 16 (Gonzalez-Bulnes *et al.,* 2005). Ovulation rate is the number of eggs produced per cycle and the rate ranges from 1 to 2 per cycle with up to 3 eggs occasionally ovulated (Schwartz and Wieerchos, 2000). Ovulation rate is reported to increase with age and then reaches a maximum at 3 to 6 years before declining gradually (Schwartz and Wieerchos, 2000). Ovulation rates may be increased by administration of gonadotropins such as eCG, FSH, human chorionic gonadotropin (hCG) and mixed gonadotropin preparations, such as PG 600® which contains 400 IU PMSG and 200 IU hCG. In general, the use of

gonadotropins to increase prolificacy has been hampered by great variability in the ovulatory response (Knights *et al*., 2003). Following ovulation, the viability of the ova ranges from 10 to 25 hours for uptimum fertilization to occur.

The use of real-time ultrasonographic techniques to monitor the pattern of antral follicular development in cattle and goats has increased the understanding of the dynamics of follicular development, growth, dominance and atresia as well as the ovulatory process (Baril *et al.*, 2000; Padilla-Rivas *et al.*, 2005). In the goat, progesterone concentrations begin to rise 2 days after oestrus to reach the peak on day 12 to 15 of the cycle (Menchaca and Rubianes, 2001; Kawu *et al.*, 2007; Wildeus, 2008; Fatet *et al.*, 2011). Progesterone level variability is related to breed and number of *corpora lutea* (Fonseca and Torres, 2005).

2.5 REGULATION OF THE OESTROUS CYCLE IN GOATS

The oestrous cycle in the doe, similar to other mammals, is controlled through the endocrine system. Importantly, the hormonal regulation of reproductive processes comprises the hypothalamo-pituitary-ovarian axis (Table 2.1). Releasing hormones from the hypothalamus (GnRH) control the function of the anterior pituitary (Figure 2.1). Gonadotropic hormones from the anterior pituitary (FSH and LH) control the functions of the ovary, involving the production of ova and hormones (Fatet *et al*., 2011). In turn, through feedback mechanism involving the hypothalamus, the steroid and protein hormones of the ovary regulate the release of the gonadotropins (Fatet *et al.*, 2011).

The gonadal steroids (estradiol and progesterone) maintain optimum conditions for reproduction through their effects on mating behaviour and the female reproductive tract. Prostaglandin $F_{2\alpha}$, produced in the uterus, is an important determinant for continuation of pregnancy or beginning of a new oestrous cycle in the doe, as it is responsible for CL regression (Figure 2.2). Other hormones produced by the placenta in some species (hCG in humans) and (eCG in mares) have gonadotropin-like effects and can be applied in biotechnological control of reproduction in goats (Figure 2.1; Fatet *et al.,* 2011).

Factors that affect the onset of oestrus in ruminants following oestrus synchronisation treatment include season, nutrition**,** stress, type of progesterone or prostaglandins, male effect and gonadotropins (Romano, 2002; Vinoles *et al.,* 2005; Bindari *et al.,* 2013; Palomino *et al.,* 2014). Poor nutrition causes irregular oestrous cycles, reduced ovulation, weak offsprings, pregnancy toxaemia and reduced twining in does (Fasanya *et al.,* 1992b; Mani *et al.,* 1992; Vinoles *et al.,* 2005; Zarazaga *et al.,* 2005; Endo and Tanaka, 2015). In a study by De Santiago-Miramontes *et al.* (2008), a 7-day nutritional supplementation in combination with socio-sexual stimulus provided by sexually active males had a positive short-term effect on oestrus behaviour and ovulatory responses of female goats. In the study, the ovulation rate at the first ovulation was greater in nutritionally supplemented does compared to non-supplemented does. The increase in ovulation rate may be due to the fact that nutritional supplementation promotes the growth of a greater number of ovulatory follicles and decreases follicular atresia in supplemented goats and ewes (Munoz-Gutierrez *et al.,* 2002). Seasonality of neuroendocrine activity is responsible for the large variation in sexual activity in temperate and subtropical breeds (Thiery *et al.,* 2002; Rivera-Lozano *et*

al., 2011), unlike in tropical breeds of goats. Lactation also influences oestrus behaviour in goats and sows due to the negative feed-back exerted by prolactin on the hypothalamo-pituitary-gonadal axis (Akusu, 2003; Zak *et al.,* 2008). Beta-carotene supplementation positively affects serum triiodothyronine concentrations around puberty in female goats by activating thyroid molecles (Meza-Harrera *et al.*, 2014). Other factors such as breed and prolific gene have been reported to affect follicular dynamics (Vinoles *et al.,* 2005). Early findings in goats show that follicle waves developing under continuous and high progesterone concentrations have smaller follicles than those developing when progesterone concentration are low. Besides, stage of the breeding season affects the number of waves in the oestrous cycle (Ginther and Kot, 1994). The occurrence of short or shortened cycles in goats could be due to different effects of high progesterone exposure on CL lifespan (Menchaca and Rubianes, 2001). During the transition into the seasonal anoestrus, the length of the inter-ovulatory cycles and the number of follicular waves are more variable (Ginther and Kot, 1994).

Table 2.1: Hormonal Regulation of the Reproductive Cycle in Female Domestic Animals

Gland	Hormone	Chemical class	Principal function
Hypothalamus	Gonadotropin-releasing hormone	Peptide	1. FSH and LH release
Anterior pituitary	Follicile-stimulating hormone (FSH)	Protein	1. Follicle growth 2. Oestrogen release
Ovary	Luteinising hormone (LH)	Protein	1. *Corpus luteum* (CL) formation and function
	Oestrogens (Oestradiol)	Steroid	1. Mating behaviour 2. Secondary sex characteristics 3. Mammary growth
	Progestins (Progesterone)	Steriod	1. Maintenance of pregnancy 2. Mamary growth
	Inhibin	Protein	1. Prevention of FSH release
Placenta	Human chorionic gonadotrpin	Protein	1. LH-like
	Equine chorionic gonadotropin	Protein	1. FSH-like
Uterus	Prostaglandin $F_{2\alpha}$	Lipid	1. CL regression 2. Parturition

(Source: Ptaszynska, 2009)

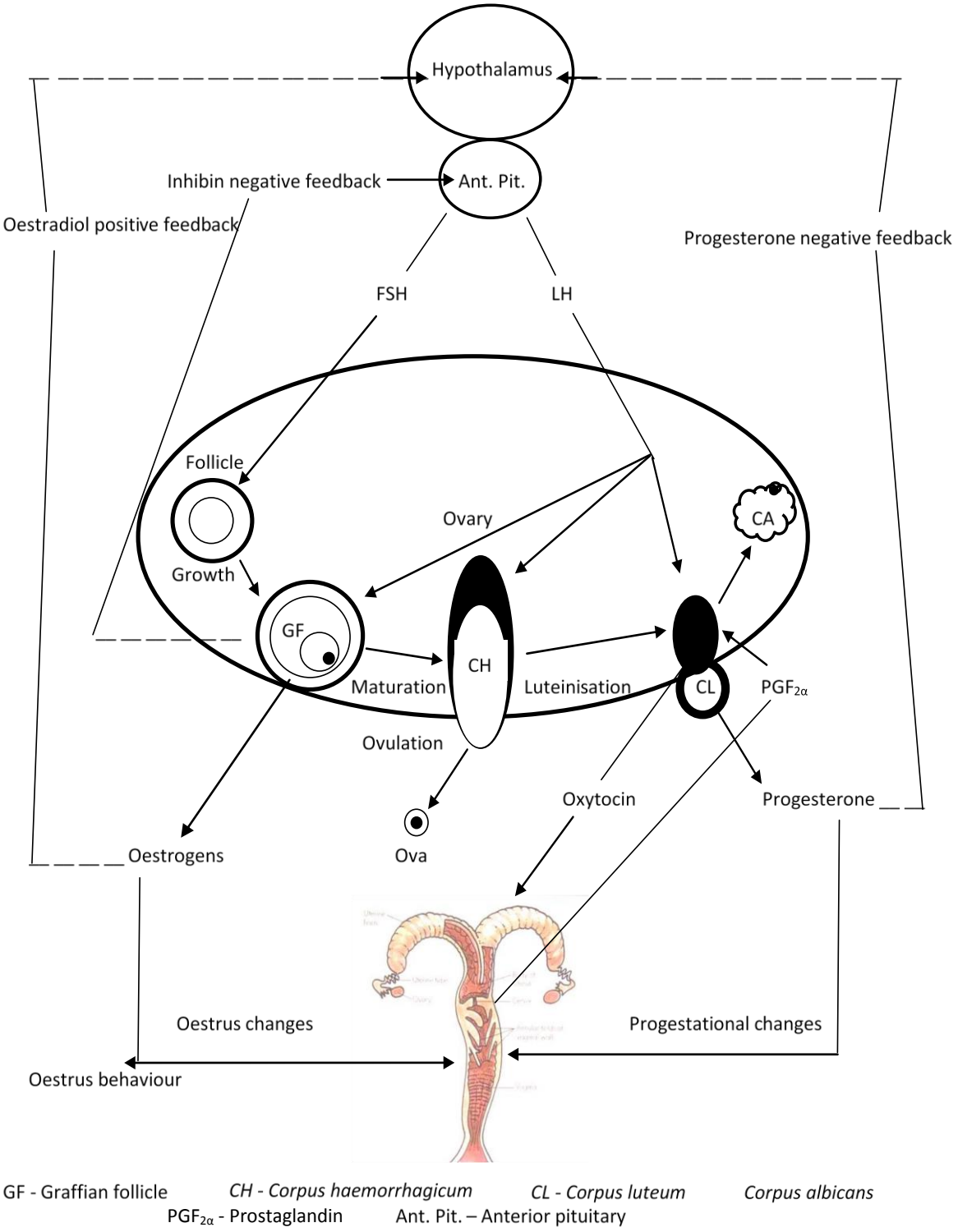


Figure 2.1: Endocrine control of reproduction in the female

(Source: Rekwot and Omontese, 2012).

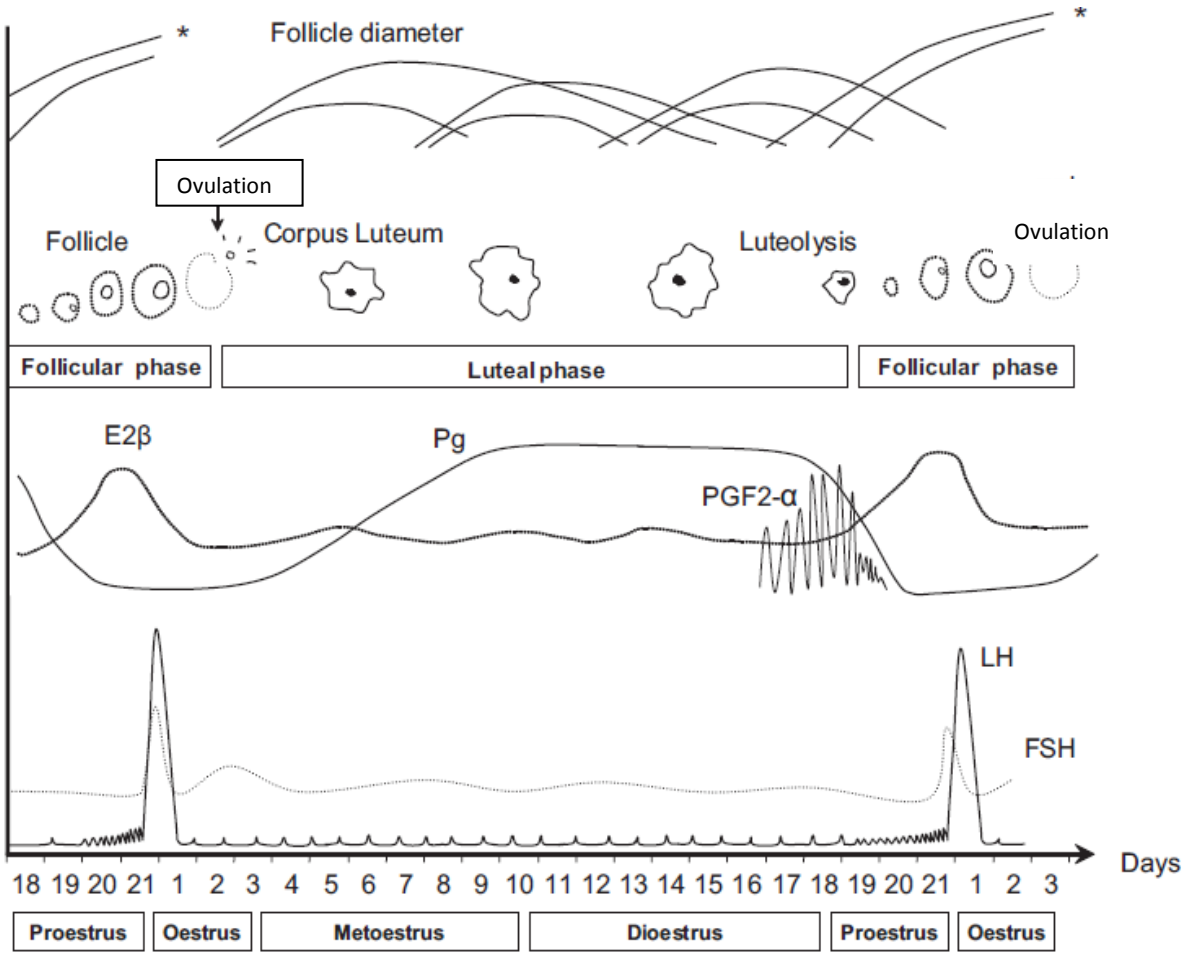


Figure 2.2: Schematic Representation of the Different Physiological Events occurring during the Oestrus Cycle in Goats: Pattern of Follicle Development. *Ovulatory follicle (s). Source: Fatet *et al.* (2011).

The interactions (Figure 2.2) are summarized as follows:

a. GnRH from the hypothalamus stimulates the release of FSH and LH from the anterior pituitary.

b. FSH stimulates production of oestradiol and inhibin by granulosa cells in the ovarian follicle.

c. Inhibin selectively inhibits release of FSH and exerts paracrine effect on other follicles.

d. When progesterone is low, high concentrations of estradiol stimulate a greater surge of GnRH, FSH, and LH by positive feed-back control.

e. LH surge stimulates ovulation of dominant follicles.

f. LH stimulates production and release of progesterone by granulosa cells in the CL.

g. High concentrations of progesterone inhibit the release of GnRH, FSH, and LH by negative feed-back control.

2.6 OESTRUS SYNCHRONISATION

Oestrus synchronisation is a reproductive management tool that enables the manipulation of either the luteal or the follicular phase of the oestrous cycle in farm animals. It may also be described as the manipulation of the reproductive cycle so that females can be bred with normal fertility during a short pre-determined interval (Kusina *et al.,* 2000; Evans *et al.,* 2001). It can be achieved basically by two methods; induction of CL regression using luteolytic agents (Kusina *et al.,* 2000; Akusu, 2003; Kawu, 2011; Omontese *et al.,* 2012) or delaying CL regression using exogenous progesterone or one of its synthetic analogues

(Abecia *et al.,* 2012; Omontese *et al.,* 2012; Oyeyemi *et al.,* 2012; Omontese *et al.,* 2013b). In a group of randomly cycling females, the time of occurrence of oestrus cannot be predicted with certainty for an individual animal. Therefore, synchronisation of oestrus and ovulation in a group of females allows the prediction of time of oestrus with reasonable accuracy. The prediction reduces the time required for detection of oestrus; or in some cases, makes it possible to breed at a fixed time without detection of oestrus (Kusina *et al.,* 2000; Fonseca *et al.,* 2005; Ungerfeld, 2011, Kawu, 2011).

In does, the opportunity for controlling the oestrous cycle is greater during the luteal phase which has a longer duration and is more responsive to manipulation (Wildeus, 2010). In cyclic domestic females, the time of oestrus is controlled by secretion of progesterone from the CL. The progesterone exerts negative feed-back on LH secretion at the level of the hypothalamus, so that the endocrine events that lead to the maturation of pre-ovulatory follicles and their subsequent ovulation are inhibited until progesterone declines at the time of CL regression. Thus, synchronisation of oestrus and ovulation really means controlling the life span of the CL (Abecia *et al.,* 2011, 2012). Since ovulation cannot occur in the presence of active CL secreting progesterone, it follows that the administration of progesterone will have the same effect. Administration of eCG shortly after cessation of progesterone treatment is reported to enhance efficiency of oestrus synchronisation (Omontese *et al.,* 2013a).

Other synchronisation strategies such as artificial light treatment with- or without melatonin administration (Wuliji *et al.,* 2003) or utilising the male effect by exposing the females to

males after a period of isolation (Fletcher *et al.,* 2002; Ungerfeld *et al.,* 2002; Martin *et al.,* 2004a; Delgadillo *et al.,* 2009) or an "ovsynch" protocol (Holtz *et al.,* 2008) were found to be successful synchronisation strategies in goats. Successful synchronisation protocols must not only establish tight synchrony, but are also expected to provide acceptable levels of fertility upon natural mating or artificial insemination (Evans *et al.,* 2001; Whitley and Jackson, 2004).

2.6.1 Prostaglandin $F_{2\alpha}$ ($PGF_{2\alpha}$)-based synchronisation

$PGF_{2\alpha}$-based oestrus synchronisation depends on termination of the luteal phase through regression of the CL to control the oestrous cycle. This system is only applicable to cycling females in which there is presence of functional CL (Abecia *et al.,* 2011, 2012). An injection of prostaglandin induces luteal regression and does can be expected to exhibit oestrus after an average interval of about 50 hours (Whitley and Jackson, 2004; Abecia *et al*., 2012). This interval to induce oestrus in goats is earlier than in sheep and cattle (Whitley and Jackson, 2004). The two commonly used products in $PGF_{2\alpha}$-based systems are $PGF_{2\alpha}$ (Lutalyse®; Pfizer) and the prostaglandin analogue cloprostenol sodium (Estrumate®; Bayer, Shawnee Mission, KS) (Silva *et al.,* 2000; Wildeus, 2010; Fierro *et al.,* 2013). A single intramuscular administration of a dose of $PGF_{2\alpha}$ or one of its analogues in the presence of a functional CL is effective in inducing luteolysis (Silva *et al*., 2000; Kanuya *et al.,* 2000; Khanum *et al.,* 2006; Ungerfeld, 2011; Fierro *et al.,* 2013). Best results are obtained in animals cycling between day 4 and 16 of the oestrous cycle (Holtz, 2005). Nuti *et al.* (1992) reported that dairy goats treated with cloprostenol (125 μg) on day 6 or 12 of the oestrous cycle showed no difference in estrous response and timing of oestrus and LH surge. The challenge is to ensure that all does in a flock have a functional CL and are ready to respond to the

administration of two $PGF_{2\alpha}$ injections, given 10 or 11 days apart (Holtz, 2005). In RS goats, double $PGF_{2\alpha}$ administration system resulted in a higher number of does in oestrus compared with the single $PGF_{2\alpha}$ administration system, although factors such as parity, nutrition and season played significant roles (Kawu, 2011; Bello, 2011; Bindari *et al.*, 2013).

2.6.2 Progesterone based synchronisation

Progesterone and its analogues (progestogens, progestagens or gestagens) are available in different forms and have been used extensively in synchronising oestrus in farm animals (Kusina *et al.*, 2000, Romano, 2002; Fonseca *et al.*, 2005; Hashemi *et al.*, 2006). Progestagens have been widely used to synchronise oestrus in small ruminants, regardless of the season (Bretzlaff and Romano, 2001). Progesterone plays a critically important role in the inhibition of the tonic mode of LH secretion in ewe (Karsch, 1984). Progestagens are employed to extend the lifespan of the CL in goats. Oestrus synchronisation using progestagens have been used in cycling does as well as in seasonally anoestrus does (Wildeus, 2010; Whitley and Jackson, 2004; Holtz, 2005; Omontese *et al.*, 2012, 2013b). The induction of supra-luteal levels increases follicular turn-over and this has become an objective in oestrus synchronisation protocols in ruminants (Diskin *et al*., 2002). The most common administration route in this synchronisation strategy is the intravaginal progestagen-containing pessaries (Holtz, 2005; Paramio and Izquierdo, 2014). These pessaries are polyurethane sponges impregnated with fluorogestone acetate (FGA) or medroxyprogesterone acetate (MAP) or they are Y-shaped silicon-coated devices ("controlled internal drug release", CIDR) impregnated with progesterone (Fukui *et al.*, 1999; Holtz, 2005; Karaca *et al.*, 2009). Implants impregnated with the highly potent

synthetic progestagen, norgestomet may be inserted under the skin of the upper side of the ear (Mellado *et al.,* 2000; Medan *et al.,* 2003b) or on the underside of the tail (East and Rowe, 1989). The subcutaneous implants devised for use in bovines ("Synchromate B" or "Crestar" Intervet) can be cut in half for use in goats (Kawu, 2000). These implants proved to be as efficient as the sponges in synchronising oestrus in goats (Kawu *et al*., 2003).

The traditional protocol when progestagens are used to synchronise oestrus consists mainly of an extended period (12-21 days) of exposure to progestagen (progesterone or a synthetic analogue) in association with an injection of eCG, administered i.m. at the end of the treatment to induce ovulation (Wildeus, 2008; Abecia *et al.,* 2011; Omontese *et al.,* 2012). The administration of eCG following progestagens treatment improved oestrus synchrony, increased number of animals responding and shortened time to onset of oestrus. It also resulted in satisfactory oestrus response (Abecia *et al*., 2011, 2012; Omontese *et al.,* 2012). However, induction of oestrus during the anoestrous season was successfully achieved in coloured Mohair goats by applying multiple injections of eCG (total of 950 IU) without any progestagen pretreatment (Karaca *et al.,* 2009).

The FGA sponges, combined with eCG for oestrus synchronisation in Sahel goats, resulted in a high kidding rate of 80 %, compared to 62 %, resulting from synchronised oestrus with FGA pessaries alone (Omontese, 2012). On the other hand, poor fertility rates were achieved with the sponge-eCG protocol due to a delay in the onset of oestrus (Maurel *et al.,* 2003). This delay is believed to be associated with the presence of anti-eCG antibodies, subsequent to repeated treatment with this agent (Baril *et al.,* 1992; Herve *et al.,* 2004). However,

animals treated with the same protocol for the first time, tended to show a large variation in the time of onset of oestrus (Baril *et al.,* 1996; Maurel *et al.,* 2003).

The synchronisation of oestrus in goats with a norgestomet implant or half-implant did not reduce the variability in oestrus occurrence and pre-ovulatory LH peak, when compared with the results attained with FGA intravaginal sponges (Freitas *et al.,* 1997). These facts suggest that factors other than eCG antibodies could play a role in affecting the response of goats to oestrus synchronisation treatments. Increasing progestagen levels at the end of a synchronisation treatment, by insertion of an additional vaginal sponge 2 or 4 days before the end of the treatment, was found not to be efficient in reducing variability among animals in the onset of oestrus. The kidding rate of the goats that received an extra sponge significantly decreased (Freitas *et al.,* 1996).

The use of intravaginal hormone-releasing devices could cause some problems related to the vaginal irritation such as vaginitis. It could also create a negative implication regarding the legal limits of progestagen residues allowed in milk of dairy goats (López-Sebastian *et al.,* 2007). Washing the vagina of the goat with a physiological solution after sponge withdrawal increased the kidding rate, especially those resulting from the first mating after synchronisation (Al-Merestani *et al.,* 2003). The results are supported by a report suggesting that the vaginal sponge creates an unsuitable medium for fertilisation in the first stimulated oestrus, resulting after the synchronisation (Manes *et al.,* 2010; Penna *et al.,* 2013). The goats tend to have variability in the occurrence of oestrus after removal of progestagen,

which leads to decreased fertility when the goats are inseminated at a pre-determined time after progesterone withdrawal (Penna *et al.,* 2013). The timing of oestrus and LH surge were less variable among goats synchronised by a progestagen treatment, when compared with goats having natural oestrous cycles. The observation suggests that physiological limits of the goat could restrict the possible improvements in oestrus synchronisation based on progestagen treatments (Penna *et al*., 2013).

Three types of intravaginal sponges impregnated with synthetic progestagens (FGA and MAP) and CIDR's impregnated with natural progesterone during the breeding season in goats were investigated and no significant differences in oestrus response and fertility between treatments were recorded (Romano, 2004). Similarly, no significant differences in oestrus response was observed in goats following oestrus synchronisation using different doses of fluorogestone acetate intravaginal pessaries (Greyling and van der Nest, 2000). On the other hand, Simonetti *et al.* (2000) used intravaginal sponges containing 40, 50 and 60 mg MAP for 14 days, and they found that the time interval from sponge removal to oestrus onset was shorter in ewes treated with lower doses of the progestagen, suggesting that dose of progestagen influence oestrus and fertility following oestrus synchronisation. Similarly, used intravaginal progesterone releasing devices containing varying amounts of progesterone decreased ovarian responses and pregnancy rates in sheep (Vilarino *et al.,* 2013). In another study, lowered fertility in Rahmani ewes during the anoestrous season was recorded following 6 days compared to 12 days treatment with 40 mg FGA intravaginal sponges plus 500 IU eCG (Amer and Hazzaa, 2009).

2.6.2.1 Short-term protocol versus long-term protocol

A practical oestrus synchronisation protocol, called short-term protocol, was developed for small ruminants to avoid the traditional trend of long-term exposure to progestagen (Menchaca and Rubianes, 2004). This protocol involves a short period of exposure to progestin (i.e. 5-7 days) compared with the 11 to 21 days progestagen treatment, and associated with a $PGF_{2\alpha}$ administration applied at the beginning of the treatment and a small dose of eCG (200-350 IU) at the end of the progestin phase. Pregnancy rates ranging from 60 to 74 % were obtained following application of the short-term protocol in goats (Rubianes *et al.,* 2001; Menchaca and Rubianes, 2007). The decrease in duration of progestagen treatment for 6 or 9 days was found to be practicable, as it caused no reduction in oestrus response with acceptable fertility and kidding rates (Fonseca *et al.,* 2005). Pregnancy rate of 64 % was achieved when the goats were synchronised for timed AI using the short-term protocol and inseminated with liquid semen 54 h after the end of the progesterone treatment, while the rate diminished to 49 % when insemination was performed 48 h after the end of the treatment (Menchaca and Rubianes, 2007).

2.7 THE "MALE EFFECT" IN DOMESTIC ANIMALS

The "male effect", otherwise known as biostimulation, refers to the biologic mechanism by which animals communicate information to conspecifics, while sexual biostimulation simply refers to the reproductive stimulation given by an animal to another of the same species (Rekwot *et al.,* 2001; Veliz *et al.,* 2006; Rivas-Munoz *et al.,* 2007; Delgadillo *et al.,* 2009; van Rooyen, 2013). This phenomenon of sexual biostimulation is also known as the "male effect" or "teasing" in sheep and goats (Delgadillo *et al.,* 2006; Martin and Kadokawa, 2006;

Delgadillo *et al.,* 2009) and bull biostimulation in cattle (Rekwot *et al.*, 2001; Fiol *et al,* 2010). The social interactions between partners of conspecifics leads to important changes in their reproductive status (Grammer *et al.*, 2005; Ungerfeld, 2007; Abecia *et al.,* 2012). Animals communicate the information using pheromones, otherwise known as cues (Rekwot *et al.,* 2001; Mostafa *et al.,* 2012; Kendrick, 2014; Simoes, 2015). The word "pheromone" originated from the Greek words *pherein* (which means to carry or transfer), and, *hormon* (which means to excite or stimulate). The teasing technique or biostimulation is a non-hormonal simple method with great potential for enhancing livestock production in the tropics and subtropics (Rekwot *et al,* 2001; Delgadillo, 2011; Chemineau, 2012; Delgadillo *et al.,* 2014). Male presence or its related characteristic traits such as sound, smell and sight has been reported to trigger oestrus and induce ovulation in sheep and goats (Avdi *et al.,* 2004; Delgadillo *et al.,* 2006; Ungerfeld, 2011). In cattle, little is known about the physiological mechanisms by which cows respond to stimulation from the bull, although most trials have focused on trying to advance postpartum rebreeding, with very diverse outcomes (Berardinelli *et al.,* 2005; Landeata-Hernandez *et al.,* 2006; Ungerfeld, 2007).

Recently, the use of the male effect in endocrine control of reproduction in females is advocated because of the move towards the reduction in the use of synthetic hormones in animal reproduction (Delgadillo *et al.,* 2004; Ungerfeld, 2007; Delgadillo *et al.,* 2015). There is a rising interest in the use of social stimulation or green, ethical and non-hormonal techniques in animal reproduction, and the possibilities that the male effect may provide is still being examined by the research community (Hawken and Martin, 2012; Delgadillo *et al.,* 2014). In "photoperiodic rigid breeds", manipulating the sexual activity season is

possible by applying alterations in the photoperiod only (Delgadillo *et al.,* 2004). Artificial long days, whether or not accompanied with melatonin administration, were successfully applied to stimulate the sexual activity of goat males out of season (Simoes, 2015). These bucks were able to induce the sexual activity of anoestrous females through the male effect (Delgadillo *et al.,* 2004; Hawken and Martin, 2012).

Male introduction is reported to result in a sustained increase in LH through increase in pulse frequency and release of the gonadotrophins (Hawken *et al.,* 2007). Ovulation, as such, occurs due to lowered sensitivity of the hypothalamus to the negative feedback action of oestrogen (Hawken *et al.,* 2009). The teasing effects of a male which stimulate both ewes and does are partly due to pheromones (Wakabayashi *et al.,* 2000, 2002; Iwata *et al.,* 2003; Ichimaru *et al.,* 2008) and partly due to olfactory cues, which constitute the main sensory input from the males at teasing (Delgadillo *et al.,* 2006; Murata *et al.,* 2014). Pheromones refer to odours secreted from the sebaceous glands, particularly those located on the head and neck of buck or ram (Wakabayashi *et al.,* 2000; 2002; Rekwot *et al.,* 2001; Iwata *et al*., 2003). The pheromone responsible for the "male effect" is produced testosterone-dependently in the skins of specific regions of the body, especially the head and neck regions (Iwata *et al.,* 2000).

In a study to examine the effects of dihydrotestosterone (DHT) on pheromone production in bucks, pheromonal activity was induced in the skins of both the head and rump regions after four weeks of the DHT treatment in castrated males (Iwata *et al.,* 2001), thus indicating a pre-requisite role of DHT in the primer pheromone production. The ram and buck

pheromones were suggested to be of the same chemical structure and have been identified as a series of 4-ethyl branched fatty acids (Iwata *et al*., 2000, 2003; Okamura and Mori, 2005). The most intense goaty odour that attracts does in oestrus was ethyl octanoic acid. Other related compounds possessing goaty odour include 4-methyl-octanoic (hircinoiac acid) which imparts a goaty flavour to mutton and goat meat (Okamura and Mori, 2005) and 4-ethyl octanoic acid, the main compound responsible for goaty flavour of milk (Iwata *et al.*, 2000, 2003). Most recently, this volatile primer pheromone is known as 4-ethyloctanal (Murata *et al.*, 2014). In humans, male ancillary secretions contain pheromones that alter the length and timing of the menstrual cycle by modifying LH-pulse and the mood of women (Preti *et al*., 2003; Grammer *et al.*, 2005). In sheep, pheromones are implicated in the mate choice selection of rams by oestrus ewes (Ungerfeld *et al*, 2006). Alarm pheromones in urine also modify behaviour of weaner pigs (Amory and Pearce, 2000).

Exposing seasonally anovulatory females to a male after an isolation period can stimulate ovulation in goat herds (Avdi *et al.*, 2004; Delgadillo *et al*., 2009). This strategy, known as "the male or buck effect", was found to be successful in initiating short ovarian cycles (5 to 7 days) in some female goats. In this case, oestrus and ovulation occur about 7 to 9 days after the induction by the buck effect, and the CL formed after ovulation is usually with a normal life-span (Chemineau *et al*., 2006). Therefore, a new post-ovulatory wave at the beginning of the cycle, in the presence of a large growing follicle and low progesterone levels seems to be the most suitable condition to promote oestrus synchronisation and its early occurrence after treatments. The common practice was to isolate the females from males (including sight, sound, and smell) for a period of time before introduction to get

reproductive response (Delgadillo *et al.,* 2004; Martin *et al*., 2004a; Chanvallon *et al*, 2010). However, complete isolation of females from males, even to the extent of considering the direction of the prevailing wind is not necessary (Delgadillo *et al.,* 2009). The first effect of the introduction of bucks to does is the increase in LH secretion, causing onset of follicular phase and increase in secretion of estrogen E_2 (Rosa and Bryant, 2002; Delgadillo *et al.,* 2004; Ungerfeld *et al.,* 2003; Martin *et al.,* 2004a). LH surge in does occurs within 6 to 8 hours after the introduction of bucks. The continuous presence of rams with ewes treated with 30 mg fluorogestone acetate (FGA) for 14 days and 200 µg $PGF_{2\alpha}$ shortened onset of oestrus (32.9±1.6 h) compared to the intermittent presence of the ram (45.3±4.4 h), and also, reduced the interval between sponge removal and ovulation (Romano *et al.,* 2001). Vasques *et al.* (2006) reported shortened time to onset of oestrus in ewes treated with 45 mg FGA for 12 days plus 500 IU eCG and the introduction of rams. The synergistic effect of salt-free-salt diet and exposure to rams improved the efficiency of oestrus synchronisation in ewes (Metodiev *et al*., 2010).

Rivas-Munoz *et al.* (2007) reported more than 90 % of does managed under grazing condition came into oestrus and ovulated at the presence of a male. The male effect induced a greater ovarian activity and shortened seasonal aneoestrus irrespective of controlled photoperiodic regimes in Criollo goats (Rincon *et al*., 2011). A combination of factors such as smell, sound, sight of the buck are reported to influence the response to the male effect (Veliz *et al.,* 2002; Ungerfeld *et al.,* 2006; Delgadillo *et al.,* 2009). Higher percentage of females became pregnant when they were in frequent contact with the male (Moore and Hall, 1992), therefore, a buck may act as an outside factor in initiating ovarian activity and

in induction of oestrus behaviour (Chemineau *et al.,* 2006; Veliz *et al.,* 2006; Delgadillo *et al.,* 2009). In ewes, the time of ram introduction (early versus. late) and type of ram presence (continuous versus. intermittent) after oestrus synchronisation affect oestrus onset and oestrus duration (Ekiz *et al*., 2009). The resumption of oestrus activity may be elicited by buck introduction into a group of anoestrus females (Chemineau *et al.,* 2006). The duration of such induced-oestrus tends to be shorter and more variable than those observed later in the breeding season (Veliz *et al.,* 2002; Chemineau *et al.,* 2006). Golkudas *et al*. (2010) reported that introduction of bulls to a buffalo herd could be a rational management strategy for reducing the postpartum anoestrus by enhancing reproductive function in buffaloes.

In a study by Ahmad *et al*. (2010), oro-nasal application of bull urine shortened postpartum period to occurrence of oestrus in cross-bred cows. This finding is similar to that observed in Bunaji and Friesian x Bunaji cows receiving nutritional supplementation and exposed to bulls (Rekwot *et al.,* 2000a, 2004). This response was, however, influenced positively by parity, body condition score and nutritional supplementation (Rekwot *et al.,* 2000; Ahmad *et al*., 2010). In another study, exposure of multiparous and primiparous beef cows to bulls during progestin (CIDR) treatment enhanced intensity of oestrus (Khanh *et al.,* 2012). Similarly, exposure of primiparous suckled beef cows to bull urine hastened resumption of postpartum luteal function (Tauck and Berardinelli, 2007). Also, presence of bulls and exposure to bull urine appeared to improve breeding performance of primiparous beef cows using a gonadotropin releasing hormone or progestin-based oestrus synchronisation protocols (Berardinelli *et al*., 2007; Tauck and Berardinelli, 2007*).*

Factors affecting the success of the male effect include the degree of contact between the two sexes (Delgadillo *et al*., 2006; Martin and Kadokawa, 2006), the duration of contact between sexes (Veliz *et al.,* 2006; Rivas-Munoz *et al.,* 2007), previous separation between sexes (Delgadillo *et al*., 2009), intensity of the libido of males (Rosa *et al.,* 2000a; Veliz *et al*., 2006) and the nature of the sensory cues from the male involved in the male effect (Veliz *et al.,* 2002; Chemineau *et al.,* 2006; Delgadillo *et al.,* 2006). Vocalisations emitted by sexually-active bucks stimulate oestrus behaviour and LH pulsatility in anoestrous does (Delgadillo *et al.,* 2006). When anoestrous does were submitted to playback vocalisations of bucks, no stimulatory effect on LH pulsatility was observed (Vielma *et al.,* 2009). It is well known that pheromonal emission can greatly be influenced by season (Walkden-Brown *et al.,* 1994a; Almeida-Irmao *et al.,* 2014) and it could be the same for other sensory cues. Another hypothesis is that bucks can adapt their vocalisation frequency according to the context or their partner (oestrous versus anoestrous female).

It is well established that the male effect is a multi-sensory phenomenon, involving olfactory, tactile, visual and auditory cues (Martin *et al.* 2004a). Several studies have shown that in female goats and sheep, exposure to hair or fleece of males stimulates LH secretion and ovulation (Avdi *et al.,* 2004; Gelez *et al.,* 2003, 2004; Ichimaru *et al.,* 2008). It is also possible that the acoustic stimulation, provided by males during the sexual season and by males receiving the photoperiodic treatment, may differ quantitatively and/or qualitatively (Walkden-Brown *et al.,* 1994b; Delgadillo *et al.,* 2006; Delgadillo *et al.,* 2011a). In addition to olfactory and visual cues, it has been reported that acoustic cues also play a role in the male effect and the respective importance of each sensory cue remains unclear (Gelez *et al.,*

2003). The auditory signals emitted by bucks are strong enough to stimulate oestrus behaviour and LH pulsatility (Delgadillo *et al*., 2009). These effects are probably mediated by the development of ovarian follicles and the consequent production of estradiol, which is a key hormone for the display of oestrus in the goat (Billings and Katz, 1997; Ungerfeld *et al.,* 2002; Delgadillo *et al.,* 2011b). The exact mechanism by which the male stimulus is delivered to the female neuroendocrine system remains to be accurately described (Rosa and Bryant, 2002).

In a study by Oyediji *et al.* (1990), the oestrus response of WAD ewes to different stimuli produced by ram exposure was studied during five successive oestrous cycles. Sniffing around the perineum was significantly superior to other stimuli in evoking the characteristic "looking-over-the-shoulder" behaviour of ewes in oestrus. Visual stimuli by a dummy ram evoked oestrus response in WAD ewes, but acted synergistically with the auditory stimuli, when accompanied by a pre-recorded ram's sexual vocalisation. The same study also reported that olfactory stimuli with a linen, liberally rubbed on an intact ram did not evoke the response ("looking-over-the-shoulder" behaviour). Molecules obtained following chemical analysis of unrine samples from cows in oestrus such as 2-butanone and oleic acid presented to bulls subjected to routine semen collection in an AI center significantly lowered ejaculation time by 21 %, and, the “1,2-dichloroethylene” combination induced a 9 % increase of sperm quantity (Le Danvic *et al.,* 2015). This has led to the development of a nasal spray containing molecules enhancing bull sexual behaviour and capacity called PheroBull®. Pregnancy rates tended to be greater in cows (60.5 %) synchronized using CIDR and exposed to bulls compared to cows (49.5 %) not exposed to bulls (Pfeiffer *et al.,*

2012). Rekwot *et al*. (2000a) reported that bull exposure hastened the resumption of postpartum ovarian activity in Bunaji cows treated with nutritional supplementation and bull exposure, compared to cows without nutritional supplementation and bull exposure (Rekwot *et al*., 2000b; Rekwot *et al.,* 2004).

In a study evaluating the influence of mature boar exposure on the remating interval and efficiency of oestrus synchronisation after weaning, it was observed that the remating interval was shortened with the onset of oestrus more synchronised in sows exposed to boars (Pearce and Pearce, 1992; Zak *et al.,* 2008; Terry *et al.,* 2013). Full physical boar exposure stimulated a high proportion of lactation oestrus in multiparous sows, however, season impacted this expression (Terry *et al.,* 2015). Thompson and Sevege (1978) also reported an earlier age at puberty and higher ovulation rate in gilts in confinement following boar exposure. Similarly, in a study to evaluate the responsiveness to boar stimuli and change in vulvar reddening in relation to ovulation in weaned sows, Langendijk *et al.* (2000) reported that combining information on vulvar reddening and boar exposure could predict ovulation within a reasonable range of two thirds of sows.

Recently, it was concluded that introduction of rams to seasonally anestrous ewes activates kisspeptin neurones and other cells in the hypothalamus leading to increased GnRH/LH secretion (Hawken *et al.,* 2007; De Bond *et al.,* 2013). It has also been reported that the absence of response of females to teasing at specific times of the year may not be due to female unresponsiveness, but to insufficient stimulation from the male (Flores *et al.,* 2000).

2.7.1 Male factors influencing the response of the female

Research into the "male effect" has revealed a great deal of information that guarantees the success of biostimulation as a tool that may be applied in "clean, green and ethical" animal production (Martin and Kadokawa, 2006). The sexual behaviour of the male is necessary to ensure the success of biostimulation i.e. inducing the preovulatory surge (Vielma *et al.*, 2013). Certain essential factors, when present in the buck ensures that optimum signals are being released so as to cause an effect in the female conspecific. Some of these factors include:

2.7.1.1 Buck libido/sexual behaviour

Studies have indicated that the sexual behaviour of a male is important in determining the response of females to the male effect. Intense sexual activity as observed in androgen-treated castrate rams induced ovulations more effectively than males that were less active (Ungerfeld *et al.*, 2006; Luna-Orozco *et al.*, 2012). Similarly, males displaying higher sexual behaviours than castrates following treatment with testosterone or oestradiol (Veliz *et al.*, 2006; Ungerfeld *et al*., 2006) and melatonin (Rosa *et al.*, 2000a) were more effective in inducing sexual activity in anovulatory ewes when teased. In addition, high sexual activity due to good nourishment in bucks provoked a higher percentage of females to oestrus than undernourished males, displaying poor sexual activity (Atti *et al.*, 2004; Ohkura *et al*., 2004). In a study to determine whether the daily exchange of photo-stimulated males among subgroups of females improved the reproductive response of anestrous goats exposed to males, it was concluded that daily exchange of photo-stimulated males among subgroups

induced an increase of their sexual behavior, but did not improve the pregnancy rates in seasonal anoestrous goats (Loya-Carrera *et al.,* 2014).

Sexual behaviour of bulls, bucks and boars has been reportedly influenced by season (Rekwot *et al.,* 1987; Paterson *et al.,* 1991; Walkden-Brown *et al.,* 1994a; Veliz *et al.,* 2002; Delgadillo *et al.,* 2004; Zarazaga *et al*., 2005, 2009) and as such affects the nature or strength of the stimuli produced by the males. Sexually inactive bucks subjected to melatonin, testosterone and/or long-day-treatments were equally effective in synchronising oestrus in anovulatory goats (Ungerfeld, 2007; Luna-Orozco *et al.,* 2012). Paterson *et al. (*1991) showed that gilts exposed to boars were least responsive during summer and most responsive in winter. Psychological, genetic, seasonal and social factors also play fundamental roles in the sexual behaviour of boars (Hemsworth and Tilbrook, 2007). In rabbit bucks, doe exposure has proven to be a biostimulation method that improves sexual drive, sperm production and quality of buck rabbits (Rodriguez-De Lara *et al*., 2000). Walkden-Brown *et al.* (1994a) reported variation in sexual activity, testosterone concentration, testicular mass and body odour of Australian Cashmere bucks during various seasons. They attributed the differences to variation in nutritional status of the bucks.

2.7.1.2 Buck vocalisation

Buck vocalisations have been reported to stimulate oestrus in anovulatory female goats during the anoestrous period (Vielma *et al.,* 2005; Delgadillo *et al.,* 2006, 2009). In a recent study involving does exposed to buck vocalisations coming from a microphone-amplifier-loud speaker system, over 85 % and 30 % of the does displayed oestrus and ovulated,

respectively (Delgadillo *et al.,* 2006). Male vocalisations alone has a greater influence on oestrus induction than ovulation in does. In sheep, auditory signals also play key roles in several aspects of behaviour (Delgadillo *et al.,* 2009).

2.7.1.3 Buck age and experience

Older males are able to elicit higher oestrus response because of the stronger buck odour (priming pheromones) which is an olfactory stimulus than pre pubertal males resulting in differences in the signals provided in the wool (presumably odors) produced by adult rams (Ungerfeld *et al.,* 2007; Delgadillo *et al.,* 2009). The lesser percentage of pregnancies obtained when yearling rams are used may be explained by differences in mounting behaviors and ejaculation frequency. The ability of older boars to advance puberty in gilts than young boars is attributed to an increased production of pheromones in older boars as influenced by age (Thompson and Sevege, 1978; Krzymoski *et al.,* 1999; Kirkwood *et al.,* 2000). Studies have shown that there is a close association between age, body weight and scrotal circumference of a males (Rege *et al.,* 2000; Karakus *et al.,* 2010). Larger scrotal circumference is highly correlated with improved reproductive soundness in bucks (Bezerra *et al.,* 2009; Agga *et al.,* 2011) and rams (Rosa *et al*., 2012; Sarlos *et al.,* 2013; Egerszegi *et al.,* 2014). In a study to determine if exposing ewes to mature rams or wethers would alter pattern of LH concentrations, McCosh *et al*. (2015) reported that LH pulse frequency increased during the transition to breeding season in ewes exposed to mature rams rather than wethers thereby hastening ovulatory activity.

2.7.1.4 Buck olfactory and chemical cues

There is great evidence that olfactory cues produced in the males play crucial roles in triggering ovulation in the female. However, maximum ovulatory responses are obtained

only when the full complement of male socio-sexual stimuli are present. Non-olfactory cues from the male either play a complimentary or synergistic role with other chemical cues from the male (Chemineau *et al*., 2006; Delgadillo *et al.,* 2009). Cue production is controlled by androgens and are usually present in skin, wool, wax, urine, faeces and fleece of males and females (Iwata *et al.,* 2003; Rampin *et al.*, 2006; Ichimaru *et al.,* 2008; Nielson *et al.,* 2013).

2.7.1.5 Buck exposure frequency and duration

Previous reports that favoured the argument that the continuous presence of stimulatory male(s) seems necessary for high frequency of LH pulses to be maintained have been contested in goats (Rivas-Munoz *et al.,* 2007) and sheep (Hawken *et al.,* 2007; 2009). However, a more synchronised distribution of oestrus was observed in ewes (Hawken and Beard, 2009) and gilts (Hughes and Thorogood, 1999; Knox *et al.,* 2002; Kemp *et al.,* 2005) exposed permanently to rams and boars, respectively. Furthermore, similar percentages in ovulations have been reported, when does are exposed to males intermittently or continuously (Veliz *et al.,* 2004, 2006; Rivas-Munoz *et al.,* 2007). In a study to evaluate the effect of duration of contact on the response of does to the buck effect, four hours of daily contact was sufficient to synchronise fertile oestrus in anoestrous does (Bedos *et al.,* 2010, 2012). Also, the introduction of novel males to females already in contact with familiar males induces ovarian activity similar to that observed in the classical male effect and this response leads to a significantly higher oestrus activity only when direct physical contact between the females and the novel males is established (Gallego-Calvo *et al.,* 2014). Although visual stimuli have not been linked to GnRH secretion in livestock species, it is clear that sheep can visually assess, identify and remember individuals (Kendrick *et al*.,

2001). Phillip and Hughes (1995) observed that pubertal response of gilts to the boar effect is enhanced when boar contact occurred several times daily compared with a single boar contact period. In the same vein, there was also a trend towards a higher proportion of gilts reaching puberty or post weaning oestrus earlier with increasing frequency of boar contact (Knox *et al*., 2002; Kemp *et al.*, 2005; Terry *et al*., 2013). Sows which commenced boar exposure on day 10 or 14, expressed an oestrus before day 21 post-partum with no significant differences in their farrowing rate or subsequent litter size (Terry *et al.*, 2015).

2.7.1.6 Buck mating stimuli

Studies in goats have shown that mechanical stimulation of the cervix shortened duration of oestrus in comparison to natural service by a buck (Romano, 1994a, 1994b). Similarly, Romano *et al.* (2000a) reported that does mounted, but not serviced had a shorter duration of oestrus than does serviced during the same period. In another study, ewes synchronised during the breeding season had a shorter time to oestrus after sponge removal when they were exposed to a ram at the time of sponge removal (Romano *et al*., 2000b). On the contrary, oestrus expression, duration of oestrus, timing and magnitude of LH release were not influenced by different types of mating stimuli in hair sheep in the tropics (Godfrey *et al*., 2001). Exposure of does to androgenized goat wethers and does also had no effect on the induction of oestrus suggesting the influence of mating stimuli on oestrus behaviour of does (Mellado and Hernandez, 1996).

In sows, natural mating stimuli appeared to prolong LH surge in comparison to artificial insemination (AI) (Zeicik *et al.*, 1981). The use of wire fencing to prevent mating between males and females is reported to reduce the efficacy of the male effect (Bartlewski *et al.*,

2002). In another study to determine the effect of mating stimuli or AI on cortisol and prostaglandin metabolite (PGFM), Norrby *et al*. (2007) confirmed that mating did not change PGFM concentrations as described earlier in sows (Madsen *et al.,* 2002) and mares (Nikolakopoulos *et al.,* 2000), whereas AI markedly increased concentrations of PGFM (Madsen *et al*., 2002; Willenburg *et al.*, 2004; Madej *et al*., 2005). Physical stimulation may play complementary roles in the overall response of the female to the male effect. Smaller litter size after artificial insemination than natural mating have been reported in sows (Tanavots *et al.*, 2002). In addition, gilts and sows respond differently to combinations of mating and AI in terms of reproductive performance and the presence of a boar during AI has a positive effect on litter size. Mating stimuli increased plasma oxytocin concentration in sows compared to AI (Norrby *et al.,* 2008).

2.7.2 Female factors influencing the response to the male

The success of biostimulation in domestic animals is also dependent on the ability of the female to receive the signals provided by the male, and the capability to process these signals and/or to respond accordingly so as to produce the desired response to the male stimulus (Zarco *et al.*, 1995). In goats, the reproductive condition of the buck appears to be the limiting factor determining the response of anoestrous does to the male effect (Flores *et al.,* 2000). In a study to evaluate the role of the vomeronasal organ (VNO) in the reproductive responses of does in terms of oestrus behaviour and conception rates subsequent to the introduction of bucks, Janse van Vuuren *et al*. (2004) reported that only 20 % of does with a non-functional VNO were pregnant, while 56 % of does with a functional VNO were pregnant after the introduction of bucks during the non-breeding season. The

VNO plays an important role in modulating oestrus in does, in response to the introduction of bucks and the buck effect (Jansen van Vuuren *et al.,* 2004). Also, doe partner preference is reported to influence the response of females to the male effect (Margiasso *et al.,* 2010). Some factors that affect the response of the female to the male effect are as follows:

2.7.2.1 Doe dominance

In a study to assess the influence of social rank of anoestrous does to the male effect after exposure to males, Alvarez *et al.* (2003) reported that high-ranking females (does with dominating behaviours) were the first to ovulate and conceive than the medium and low-ranking females (does with shy and fearful behaviours). This may be explained by the fact that oestrus females compete for contact with males and such the degree of contact between females and males influences the response to the male effect (Alvarez *et al.,* 2003, 2007, 2009; Chemineau *et al.,* 2006). Closer contact of does with bucks resulted in faster response and a higher proportion of females exhibiting oestrus (Alvarez *et al.,* 2003, 2007). In addition, subordinate sows showed fear-related behaviour in response to boar stimulation even when they were in standing oestrus resulting in impaired heat detection and mating (Krzymoski *et al*., 1999; Pedersen *et al.,* 2003). In cattle, social behaviour or ranking is affected by the health condition of the livestock resulting in altered reproductive activities (Galindo and Broom, 2000).

2.7.2.2 Doe age, experience and temperament

It is reported that sexually naive and young ewes present a reduced response to the male odour, compared to sexually-experienced ewes (Gelez *et al.,* 2003, 2004; Chanvallon *et al.,*

2010). Similarly, Chanvallon *et al*. (2010) reported that "nervous" ewes responded better to the male effect than "calm ewes" following exposure to sexually active rams. The authors concluded that the sexual experience and temperament of ewes should be considered when flock management involves the ram effect. In the porcine, studies have shown that the timing and synchrony of pubertal oestrus attainment are significantly improved, when first boar exposure of gilts is delayed until 182 days of age (van Wattere *et al.,* 2006). The age of does especially in relation to social rank status has also been reported to influence the response to the buck effect and reproductive success (Cote and Festa-Bianet, 2001). Ekiz *et al.* (2013) reported that previous sexual experience with males improved the expression of sexual behaviours in Kıvırcık ewes exposed to rams during progestagen treatment. On the contrary, Walkden-Brown *et al*. (1994b) and Delgadillo *et al.* (2009) reported that lack of sexual experience of does not reduce the responses of LH, oestrus or fertility in anoestrous goats exposed to sexually active males.

2.7.2.3 Doe isolation prior to teasing

One of the dogmas that has been associated with the male effect is that complete isolation of the female prior to male exposure is essential for the male effect to be effective (Delgadillo *et al.,* 2009). However, recent studies have demonstrated that introduction of a novel male to a herd of males and females stimulated LH secretion in the does and ewes (Veliz *et al.,* 2006; Hawken and Beard, 2009). This is because females may be able to learn and remember the identity of novel and familiar males, thus, explaining the ability of novel rams to induce ovulation in ewes that have had limited or direct contact with other rams before teasing (Cushwa *et al.,* 1992; Levy *et al.,* 2004). Therefore, since novel males can stimulate

ovulation in females maintained in continuous contact with familiar males, then the male effect in small ruminants is similar to pheromone-based phenomena reported in rodents (Delgadillo *et al.,* 2009).

2.7.2.4 Doe nutritional or reproductive status

Nutrition plays a major role on enhancing reproductive efficiency in all animals (Bindari *et al*., 2013; Endo and Tanaka, 2015). Metodiev *et al.* (2010) reported that ewes treated with the ram effect and salt-free-salt diets improved fertility rates of ewes. Ovulation rate in anoestrous female goats managed under grazing conditions and exposed to the male effect was increased by nutritional supplementation (Tanaka *et al.,* 2003, 2004; De Santiago-Miramontes *et al.,* 2008). Furthermore, Fitz-Rodríguez *et al.* (2009) reported that nutritional supplementation improves ovulation and pregnancy rates in female goats managed under natural grazing conditions and exposed to the male effect. Similarly, lesser ovulation rate was observed in under-nourished ewes (Abecia *et al.,* 2006). Does with decreasing body weights (BW) and poor body condition scores (BCS) that were subjected to the male effect showed poor reproductive performance that could have been due to low plasma insulin concentrations in does (Gallego-Calvo *et al.,* 2015; Endo and Tanaka, 2015).

The stage or reproductive status of a female may affect ovulation in response to the male effect (Ungerfeld *et al.,* 2002; Hawken and Martin, 2012). For example, during deep anoestrous in lactating goats subjected to treatment with artificially long days and natural photoperiod, highly synchronous and fertile reproductive activity was induced by the male effect (Pellicer-Rubio *et al.,* 2007). However, the ovulatory response of anoestrous goats

exposed to the male effect in the subtropics was reported to be unrelated to the follicular diameter of does at male exposure (Delgadillo *et al*., 2011b). In pigs, boar exposure during lactation decreases the interval from weaning to oestrus in sows, thus, suggesting that the boar effect increases LH pulse frequency, which eventually leads to oestrus behaviour in the sow as observed during intermittent suckling and split weaning (Krzymoski *et al.,* 1999; Zak *et al*., 2008; Soede *et al.,* 2012; Terry *et al.,* 2013). Sexually experienced male rats display penile erections, when exposed to faeces from mammalian females in oestrus, suggesting that the stage of the oestrus cycle affects pheromone release in females (Rampin *et al.,* 2006).

2.7.2.5 Doe parity and maturity

Higher sexual activity has been reported in multiparous anestrous does than nulliparous anoestrous does exposed to the male effect (Delgadillo *et al.,* 2002; Veliz *et al*., 2002; 2009). The increased sexual behaviour of multiparous females suggests that parity influenced the response to the male effect. However, Luna-Orozco *et al.* (2008) and Veliz *et al*. (2009) observed similar response of both multiparous and nulliparous anoestrous does to sexually active males irrespective of parity. In another study by Mellado *et al.* (2000), higher oestrus response was recorded in mature norgestomet-treated does than pre-pubertal norgestomet-treated does (92 % versus 16.6 %) exposed to the buck effect.

2.7.2.6 Doe hormonal treatments prior/during exposure to male stimulus

The synergistic effect of hormonal treatments (gonadotrophins, progestagens and prostaglandins) with the male effect has been reported in does (Mellado *et al.,* 2000; Veliz *et al.,* 2002; Keskin, 2003; Zarazaga *et al.,* 2009), ewes (Ungerfeld *et al.,* 2003; Evans *et al.,*

2004; Ungerfeld, 2011) and cows (Berardinelli *et al.,* 2007). Recent studies have also shown that the timing of puberty attainment and oestrus detection are significantly improved when PG600-treated gilts are exposed to experienced full boar contact (Bartlette *et al.,* 2009). In sheep, the degree of sexual attractiveness of oestrus ewes to rams is reported to decrease with intravaginal sponge treatment (Gatti and Ungerfeld, 2012). This has been attributed to alteration in normal vaginal microbial flora and secretions. As a result, recent studies favour short-term intravaginal progestin treatment to minimize the effect of long-term intravaginal pessaries treatment on vaginal bacterial flora and secretions (Rubianes and Menchacha, 2003; Abecia *et al.,* 2012).

2.8 THE "FEMALE EFFECT" IN DOMESTIC ANIMALS

A less studied component of social stimulation is the "female effect" which is defined as the influence of the reproductive stage of female animals on other females or male-conspecifics (Walkden-Brown *et al.,* 1994b; Zarco *et al.,* 1995; Carrillo *et al.,* 2011; Nielson *et al,* 2013). Theoretically, this phenomenon is mediated by pheromone signals transferred to the hypothalamus from the VNO through the accessory olfactory nerve (Keverne, 2002; Jansen van Vuuren *et al*., 2004; Ungerfeld *et al.,* 2006) and the activation of the pre-optic area (anterior hypothalamus), which is highly involved in sexual behaviour (Savic *et al.,* 2005). Males exhibit an androgen-dependent chemosensory ability to discriminate between oestrus and non-oestrus female odours in mice (Achiraman *et al*., 2014). Fertile oestrus can be induced in anoestrous female sheep and goats by exposing them to other females induced to oestrus with eCG (Rodríguez-Martínez *et al.,* 2013). In addition, female-female interaction triggers the stimulation of the reproductive cycle, leading to the sexual arousal of bucks.

Prado *et al.* (2003) reported that in goats, continuous exposure of a buck to an oestrus female stimulates sexual activity and increases sperm output. Vázquez and Orihuela (2001) demonstrated that vaginal mucus from oestrus ewes smeared on the muzzles of ram lambs increased their testosterone levels within 2 hours after application. However, vulvovaginal mucus of ewes in oestrus failed to significantly influence sperm concentration and reaction time of rams during semen collection (Aguirre *et al*., 2011). It is possible that the presence of only 1 or 2 female odours was not enough to sexually stimulate rams because of the lack of visual and tactile stimulations that interact with olfaction to sexually stimulate the rams in the study. Apparently, longer periods of stimulation of males using vaginal mucus of oestrus females are needed (Aguirre *et al.,* 2011). In a study to test the hypothesis that permanent and close contact with females stimulates testosterone production and enhances fresh seminal characteristics of pampas deer, Villagran and Ungerfeld (2013) concluded that contact with females stimulates reproductive patterns of male pampas deer, resulting in better fresh semen characteristics before rutting and higher testosterone concentrations during the rut.

Exposure of sexually inactive bucks and rams to oestrus females is an inexpensive, practical and efficient way to elicit sexual activity in males (Rosa *et al.,* 2000b; Jorre De St Jorre *et al*., 2008; Carrillo *et al.,* 2011). Pre-pubertal gilts exposed to sows and gilts in oestrus reached puberty earlier than gilts not exposed to sows and gilts in oestrus (Peacock and Hughes, 1995). Similarly, the presence of large number of ewes in oestrus stimulate ovarian activity in seasonally anoestrous ewes (Zarco *et al.,* 1995). In goats, Restall *et al.* (1995) reported that unequivocally, oestrus females induced ovulation in anovulatory does because

the influence of the female on social interaction involved in synchronised mating is significant. Similarly, vocalisations and tail wagging, which are oestrus indicators were socially facilitated within groups of anoestrous does exposed to oestrus females under typical pasture grazing conditions (Hogan *et al.*, 2004).

A positive relationship between sexual behaviour of male lambs towards oestrual ewes was reported in 5-6 month-old lambs, exposed to ewes in oestrus (Ungerfeld *et al*., 2007). Although males have long been known to have a stimulatory effect on females, it is also true that in some species, females can have a similar stimulatory effect on females and males. For example, the presence of females influences the efficacy of semen collection in male goats (Silvestre *et al.,* 2004). In a study to evaluate the influence of female presence on efficiency of semen collection, libido re-establishment and semen characteristics of bucks, Prado *et al.* (2002) concluded that the simultaneous presence of two females while semen of bucks are collected reduced the number of mounts performed before the second ejaculation and the latency between ejaculations.

2.9 INFLUENCE OF SEASON ON ANIMAL REPRODUCTION

Climate and geographical location influence oestrus and ovulation in domestic animals (Lopes *et al.,* 2001; Mellado and Heza-Harrera, 2002; Thiery *et al.,* 2002). In order to ensure that food resources are available to meet the demands of reproductive activities, animals have evolved strategies to ensure that periods of abundant food coincide with late pregnancy and lactation by linking sexual activity to changes in photoperiod (Martin *et al.,* 2004b). The effect of season on reproduction is more evident in the temperate countries, where sheep and

goats are seasonally polyoestrous (Guiseppe and Giovanni, 2002; Nakao *et al.,* 2008). On the other hand, sheep and goats exhibit oestrus all year round, although environmental factors such as rainfall and feed availability modify their reproductive activity (Martin *et al.,* 2004b). Seasonal changes in reproductive activity are mediated by neuro-endocrine control mechanisms, associated with the frequency in release of GnRH (Goodman *et al.,* 2000; Thiery *et al.,* 2002).

High concentrations of progesterone in females in the mid-luteal phase blocks the response to the male effect during the breeding season (Hawken *et al.,* 2009). Increased oestrus behaviour was reported in Saanen goats during the late rainy and early-dry seasons (Lopes *et al.,* 2001), while Zimbabwean goats exhibited more oestrus during the cold-dry season (Llewelyn *et al*., 1993). Savanah Brown goats exhibited more oestrus activity following prostaglandin treatment in the cold-dry season than in the rainy season (Kawu, 2011). Higher conception rates have been reported in Mexican goats during the cooler seasons than the warmer seasons, suggesting the influence of season on ovarian activity (Mellado and Meza-Harrera, 2002). In an oestrus synchronisation programme using intravaginal progestagen sponge treatment in female Blanca Andaluza goats, Zarazaga *et al*. (2014) reported that oestrus and ovulatory responses were better influenced by season rather than body condition score.

In Australia, higher pregnancy rates in sheep and goats were reported following mating in April than in September, while ovulation peaked in June (Restall, 1992). Greater ovarian activity has been reported in Yankasa sheep during the early-rainy season, with peak lambing occurring from August to November (Molokwu and Ummuna, 1980); while oestrus

duration was longer in the hamattarn season (33.6 hours) than in the hot-dry season (24 hours) (Igono *et al.,* 1982a). Likewise, higher fertility rates were reported in WAD does following breeding of both RS and WAD goats during the early dry season, suggesting the influence of season and breed on non-return rates of oestrus (Nwoko and Ibe, 2005). In the tropics, increased infertility in livestock has been attributed to heat stress (Ozawa, 2005). Summer heat stress lengthens the oestrous cycle and decreases the intensity and duration of oestrus, thereby resulting in reduced fertility and increased embryonic deaths (Roth *et al.,* 2002; Marai *et al.,* 2007; Dobson *et al.,* 2012).

In addition, high ambient temperatures have been associated with seasonal anoestrus in small ruminants (Dobson *et al.,* 2012). Heat stress impairs oocyte growth, protein synthesis and DNA transcription, required for subsequent embryonic development (Al-Katanani *et al.,* 2002). In Northern Nigeria, longer duration and intensity of oestrus in the rainy and pre-dry seasons in both White Fulani and Sokoto Gudali cows have been reported (Zakari *et al.,* 1981). However, Eduvie (1985) and Rekwot *et al*. (2000a) showed that earlier resumption in postpartum activity and complete uterine involution in Bunaji cows favour calving in the dry season than in the rainy season. It was concluded that cows calving in the dry season and exposed to vasectomized bulls (biostimulation) take advantage of abundant availability of crop residues during the early dry season (November – February) and the improved regrowth and abundant lush pasture of the early rains (April – May) to meet their total requirements for maintenance, growth and reproduction (Rekwot *et al.,* 2000a). In another study investigating fertility rates of Zebu cattle (*Bos indicus*) after prostaglandin

administration and AI, overall pregnancy rate was higher in the rainy season than dry season (Rekwot *et al.,* 1999).

The influence of season, ovulation rates, AI using pre-determined ejaculate concentration and reproductive status of does on progesterone secretion pattern and oestrus behaviour have been well established in RS and WAD goats (Pathiraja *et al.,* 1991; Fasanya *et al.,* 1992a, 1992b; Akusu *et al.,* 1994; Kawu *et al.,* 2007; Leigh and Ajibade, 2010). Oestrus duration was longer during the dry season, especially late-dry seasons, compared with the rainy season of the year in WAD goats. This finding was attributed to shorter grazing periods and reduced rumination rates during the rainy season (Ogede *et al.,* 1996; Akusu, 2003). Hence, nutrition is an essential element that influences reproductive behaviour and fertility in goats (Endo and Tanaka, 2015. However, season of the year did not have significant influence on gestation length of does and birth weight of kids in rainforest zone of Nigeria (Akusu, 2003).

Sheep breeds show reproductive seasonality, and, therefore, maintain different levels of photo-responsiveness and this variation in reproductive activity observed mostly in mid- and high-latitude sheep breeds, is weak or non-existent in breeds that originated near the Equator (Gondogan *et al*., 2003; Gómez-Brunet *et al.,* 2008). Factors such as breed, nutrition, socio-sexual, temperature, lambing date and lactation period can modulate photo-periodical influences (Martin *et al.,* 2004a, b; Forcada and Abecia, 2006; Scaramuzzi and Martin, 2008). Goats also show seasonality patterns in reproductive activities similar to sheep (Walkden-Brown *et al.,* 1994a). Although goats are normally continuous breeders in the tropics, they may experience anoestrous when feed is scarce. Photoperiodic treatments

coupled with buck effect allow synchronisation of ovulation but fertility results are poorer than those following hormonal treatments (Fatet *et al*., 2011). Similarly, cows found in high latitudes concentrate calving in the spring (Borisenkov *et al.*, 2004). Domestication and selection for all year round breeding have been successful in cattle, but an endogenous biologic rhythm exists especially under extreme conditions (Stumpf *et al*., 1993).

In the summer and early autumn, periods of infertility, late pregnancy and early pregnancy disruption are reported to be frequent in both sows and gilts (Tast *et al.,* 2002; Bertoldo *et al.,* 2009). Just like other livestock in the tropics, swine can normally breed throughout the year, if food and housing are adequate (Macchi *et al.,* 2010). In the mid- and high-latitudes, the combination of hormonal treatments and photoperiod manipulation are effective in mitigating seasonal infertility. The economic implication, however, precludes the widespread application of this practice (Bassett *et al.,* 2001). External factors influencing the attainment of puberty and the oestrous cycle in gilts include the detection of oestrus, the season of the year during the sexual development, the confinement environment, boar exposure, nutrition and disease (Tummaruk *et al.,* 2004). Seasonal infertility in prepuberal, cycling, lactating, and anestrus sows may be treated using gonadotropins so as to decrease the weaning-to-estrus interval (WEI) and subsequent fertility (Tummaruk *et al.,* 2007). Knowledge on the influence of factors such like farm managment, season and breed on the oestrous pattern and ovulation time of individual sows would allow the use of a more precise strategy for artificial insemination (Johnson *et al.,* 2000).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Location of Study

The study was carried out at the goat farm of the Small Ruminant Research Programme, National Animal Production Research Institute (NAPRI), Shika, Ahmadu Bello University, Zaria. NAPRI is located in the Northern Guinea Savannah of Nigeria between latitude 11 $^{\circ}$N and 12 $^{\circ}$N and between longitude 7 $^{\circ}$E and 8 $^{\circ}$E at an elevation of 650 m above sea level.

3.2 Seasons of the Study Area

This study was carried out in the dry (November – April) and rainy (May – October) seasons. In the study area, the harmattan season, occurring between November and February is characterized by cold weather and dry dust-laden winds. Meteorological data (rainfall, relative humidity, ambient temperature, wind speed, duration of sunshine hours) from the study periods were obtained from the Institute for Agricultural Research, Ahmadu Bello University, Zaria, located in a distance of about 10 kilometers from the experimental site (Table 3.1). In the dry and rainy seasons, daily minimum and maximum temperature ranged from 17 ^{o}C to 34 ^{o}C and 20 ^{o}C to 34 ^{o}C, respectively. Mean relative humidity fluctuated between 17 % to 20 %; and 61 % and 74 % in the dry and rainy seasons, respectively. Average monthly rainfall varied from 0 mm in the dry season to 334 mm during the rainy season.

3.3 Experimental Animals and Herd Management

Red Sokoto (RS) and Sahel (SH) does, with body condition score range of 2-4 (Mellado *et al*., 2004) and aged 2-3 years, were used in this study. Only Red Sokoto and Sahel bucks with BCS greater than 3 and high libido were used for breeding. Experimental animals were identified by means of plastic ear tags, screened for blood and helminth parasites, and appropriate treatments and vaccinations were carried out. Experimental animals were grazed on native pastures during the day time, fed *Digitaria smutsii* hay and concentrate supplement (0.5 kg/head/day), and water provided *ad libitum*. They were housed in pens with large paddocks during the daytime for grazing. They were dipped once weekly during the dry season and twice weekly during the rainy season in Coumaphos (Asuntol®, Bayer) an organophosphate acaricide at a dilution of 1 litre of 16 % coumaphos to 800 litres of water for the control of ectoparasites. Does that kidded more than 5 months earlier had their kids withdrawn at least 1 month before the commencement of the study. A minimum distance of about 500 m was used to separate the buck-exposed from the non-exposed does so as to minimize influence of exteroceptive stimuli associated with each other.

3.4 Experimental progestagens/exogenous hormones

Does were treated with CIDR, FGA-30 mg or FGA-45 mg for 14 days. The CIDR is a T-shaped intravaginal implant, containing 300 mg natural progesterone (Eazi-Breed CIDR, InterAg, Hamilton, New Zealand) and impregnated in a silicon elastomer core. The FGA-30 or 45 mg FGA (FGA, Chronogest, Intervet S.A., Angers, France) are intravaginal pessaries containing 30 and 45 mg of fluorogestone acetate, respectively.

3.5 Experimental Design

3.5.1 Experiment 1: Influence of continuous buck exposure during progestagen treatment and season on oestrus behaviour and fertility of Red Sokoto goats

A total of 180 RS does were randomly allocated into four treatments in the dry season (n = 96): (1) exposed to aproned buck only (BE, n = 28); (2) exposed to aproned buck and treated with CIDR (BECD, n = 28); (3) CIDR implant only (CD, n = 20); (4) Control (CN, n = 20). During the rainy season (n = 84), RS does were also allocated into four groups as follows: (1) exposed to aproned buck only (BE, n = 22); (2) exposed to aproned buck and treated with CIDR (BECD, n = 22); (3) CIDR implant only (CD, n = 20); (4) Control (CN, n = 20), (Figure 3.1).

3.5.2 Experiment 2: Effect of limited buck stimulus and season on oestrus behaviour of progesterone-treated Sahel goats

A total of 114 Sahel does were randomly allocated into four treatments in the dry (n = 94) and rainy (n = 120) seasons: (1) teasing for 7 days only (aproned buck exposure and no CIDR implant, BE); (2) teased for 7 days before Eazi-Breed CIDR insert (CIDR; 14 days treatment with 330 mg progesterone) implant withdrawal (aproned buck exposure plus CIDR implant, BECD); (3) CIDR implant for 14 days only (No aproned buck exposure and treated with CIDR, CD); (4) control (no aproned buck exposure no CIDR implant, CN) (Figure 3.2).

3.5.3 Experiment 3: Influence of continuous buck exposure, season and dose of fluorogestone acetate on oestrus behaviour and fertility of Red Sokoto goats

A total of 216 Red Sokoto does were randomly allocated into four treatments in the dry season (n = 96): (1) exposed to aproned buck and treatment with FGA-30 mg (BEF3, n = 28); (2) exposed to aproned buck and treated with FGA-45 mg (BEF4, n = 28); (3) treated with FGA-30 mg only (F3, n = 20); (4) treated with FGA-45 mg only (F4, n = 20), and rainy season (n = 120): (1) exposed to aproned buck and treated with FGA-30 mg (BEF3, n = 30); (2) exposed to aproned buck and treated with FGA-45 mg (BEF4, n = 30); (3) treated with FGA-30 mg only (F3, n = 30); (4) treated with FGA-45 mg only (F4, n = 30) (Figure 3.3).

3.5.4 Experiment 4: Influence of male stimulus, dose of fluorogestone acetate and season on oestrus and fertlity responses of Sahel goats

A total 212 SH does were randomly allocated into four treatments in the dry season (n = 92): (1) exposed to aproned buck and treatment with FGA-30 mg (BEF3, n = 24); (2) exposed to aproned buck and treated with FGA-45 mg (BEF4, n = 24); (3) treated with FGA-30 mg only (F3, n = 22); (4) treated with FGA-45 mg only (F4, n = 22), and rainy season (n = 120): (1) exposed to aproned buck and treated with FGA-30 mg (BEF3, n = 30); (2) exposed to aproned buck and treated with FGA-45 mg (BEF4, n = 30); (3) treated with FGA-30 mg only (F3, n = 30); (4) treated with FGA-45 mg only (F4, n = 30) (Figure 3.4).

3.5.5 Experiment 5: Serum progesterone levels of Red Sokoto does treated with different progestagens and continuous exposure to buck effect

Red Sokoto (RS) does (n=18) were randomly allocated into six groups (n=3/group): (1) aproned buck exposure and controlled internal drug release (CIDR) treatment (BECD); (2) CIDR treatment only (CD); (3) aproned buck exposure and FGA-30 mg treatment (BEF3); (4) FGA-30 mg treatment only (F3); (5) aproned buck exposure and FGA-45 mg treatment (BEF4) and (6) FGA-45 mg treatment only (F4). Intravaginal progestagens (CIDR, FGA-30 mg or FGA-45 mg) were inserted for 14 days with or without buck exposure on day 7 to the end of progestagen treatment (Figure 3.5). Following removal, does were placed for five days with intact bucks to detect oestrus.

3.5.6 Experiement 6: Serum progesterone profiles of Sahel does treated with progestagens with or without exposure to buck effect

SH does (n = 18) were randomly allocated into six groups (n = 3/group): (1) aproned buck exposure and controlled internal drug release (CIDR) treatment (BECD); (2) CIDR treatment only (CD); (3) aproned buck exposure and fluorogestone acetate (FGA)-30 mg treatment (BEF3); (4) FGA-30 mg treatment only (F3); (5) aproned buck exposure and FGA-45 mg treatment (BEF4) and (6) FGA-45 mg treatment only (F4). Intravaginal progestagens (CIDR, FGA-30 mg or FGA-45 mg) were inserted for 14 days with or without buck exposure on day 7 to the end of progestagen treatment (Figure 3.6). Following removal, does were placed for five days with intact bucks to detect oestrus.

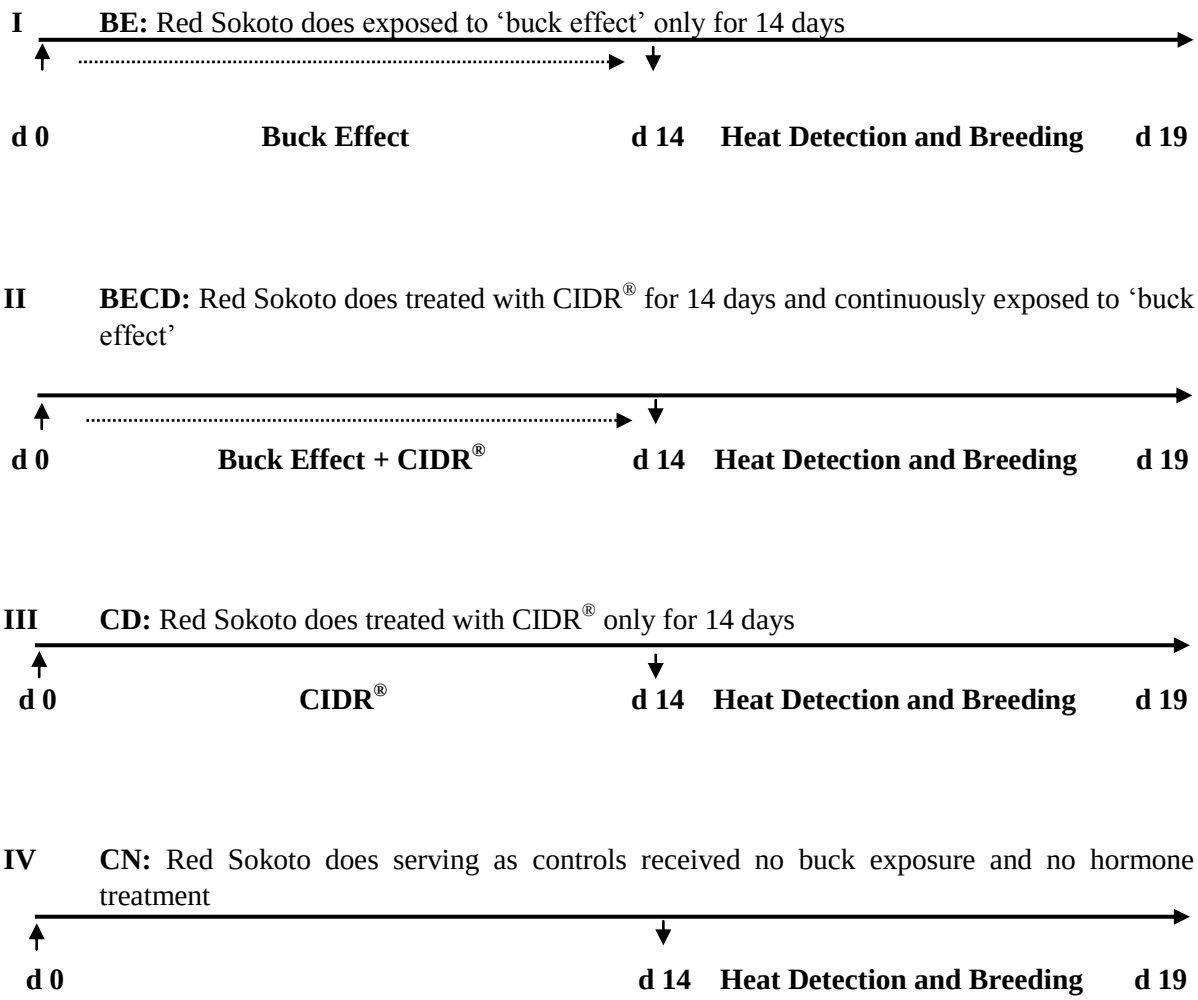


Figure 3.1: Treatment protocol summary for oestrus synchronisation in Red Sokoto does using CIDR and exposure to aproned bucks.

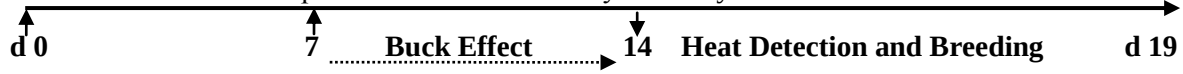
d = Experimental day ⋯⋯▸ = Duratiion

BE = Aproned buck exposure only CD = CIDR only

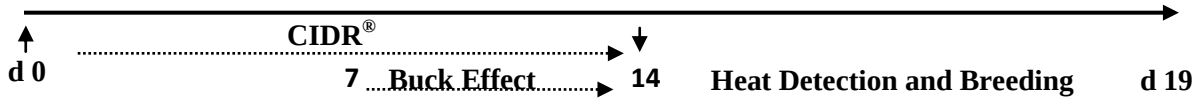
BECD = Aproned buck exposure and CIDR CN = Control

CIDR = Controlled internal drug release device

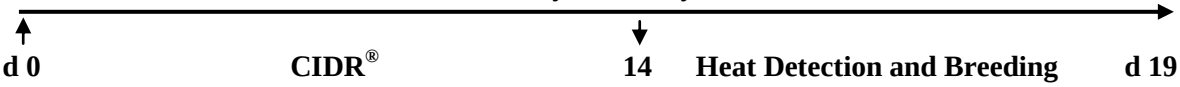
I **BE:** Sahel does exposed to 'buck effect' only for 7 days



II **BECD:** Sahel does treated with CIDR® for 14 days and exposed to 'buck effect' 7 days before CIDR withdrawal



III **CD:** Sahel does treated with CIDR® only for 14 days



IV **CN:** Sahel does serving as control received no buck exposure and no hormone treatment

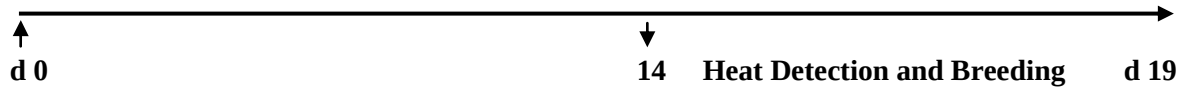


Figure 3.2: Treatment protocol summary for oestrus synchronisation of Sahel does using CIDR and exposure to aproned bucks.

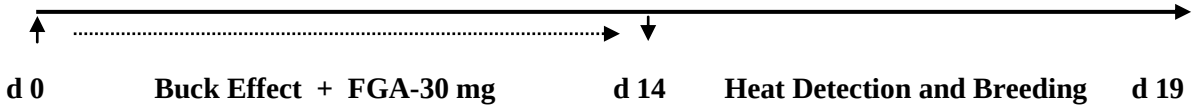
d = Experimental day ⋯▸ = Duratiion

BE = Aproned buck exposure only CD = CIDR only

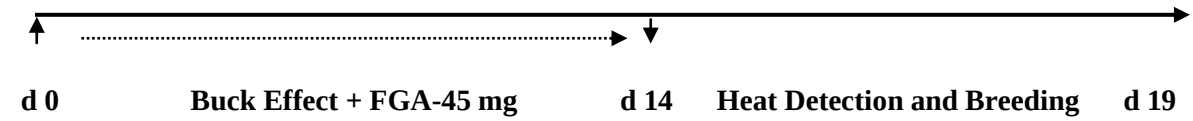
BECD = Aproned buck exposure and CIDR CN = Control

CIDR = Controlled internal drug release device

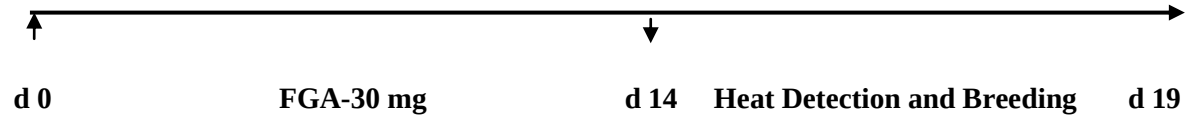
1 **BEF3:** Red Sokoto does exposed to 'buck effect' and treated with intravaginal sponge impregnated with 30 mg fluorogestone acetate (FGA-30 mg) for 14 days.



2 **BEF4:** Red Sokoto does exposed to 'buck effect' and treated with intravaginal sponge impregnated with 45 mg fluorogestone acetate (FGA-45 mg) for 14 days.



3 **F3:** Red Sokoto does not exposed to 'buck effect' and treated with intravaginal sponge impregnated with 30 mg fluorogestone acetate (FGA-30 mg) only for 14 days.



4 **F4:** Red Sokoto does not exposed to 'buck effect' and treated with intravaginal sponge impregnated with 45 mg fluorogestone acetate (FGA-45 mg) only for 14 days.

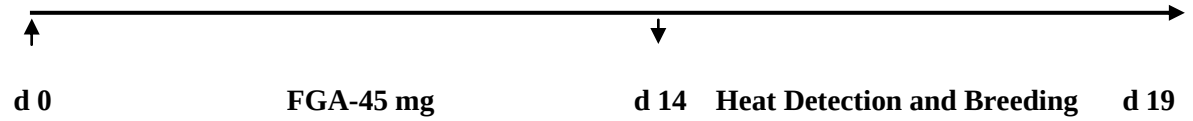


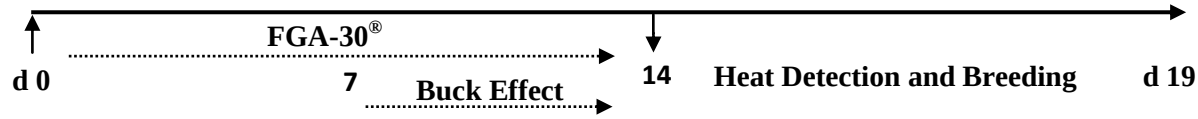
Figure 3.3: Treatment protocol summary for oestrus synchronisation in Red Sokoto does using FGA (30 mg and 45 mg) and buck effect.

d = Experimental day ⋯⋯▸ = Duration

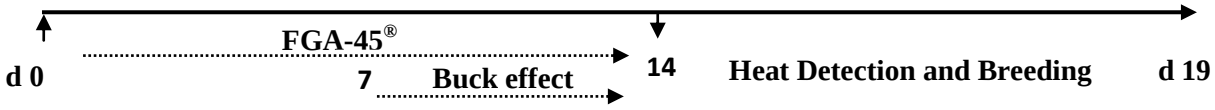
BEF3 = Aproned buck exposure and FGA-30 F3 = No buck exposure and FGA-30

BEF4 = Aproned buck exposure and FGA-45 F4 = No buck exposure and FGA-45

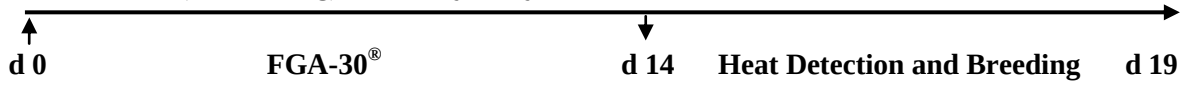
I **BEF3:** Sahel does treated with intravaginal sponge impregnated with 30 mg fluorogestone acetate (FGA-30 mg) for 14 days and exposed to 'buck effect' for 7 days before pessaries withdrawal.



II **BEF4:** Sahel does treated with intravaginal sponge impregnated with 45 mg fluorogestone acetate (FGA-45 mg) for 14 days and exposed to 'buck effect' for 7 days before pessaries withdrawal.



III **F3:** Sahel does treated with intravaginal sponge impregnated with 30 mg fluorogestone acetate (FGA-30 mg) for 14 days only.



IV **F4:** Sahel does treated with intravaginal sponge impregnated with 45 mg fluorogestone acetate (FGA-45 mg) for 14 days only.

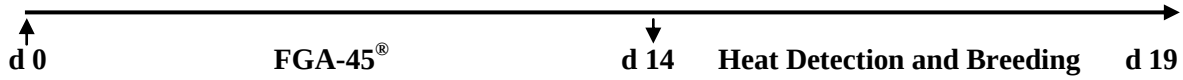


Figure 3.4: Treatment protocol summary for oestrus synchronisation in Sahel does using fluorogestone acetate and limited exposure to aproned bucks.

BEF3 = Aproned buck exposure and FGA-30

BEF4 = Aproned buck exposure and FGA-45

F3 = No buck exposure and FGA-30

F4 = No buck exposure and FGA-45

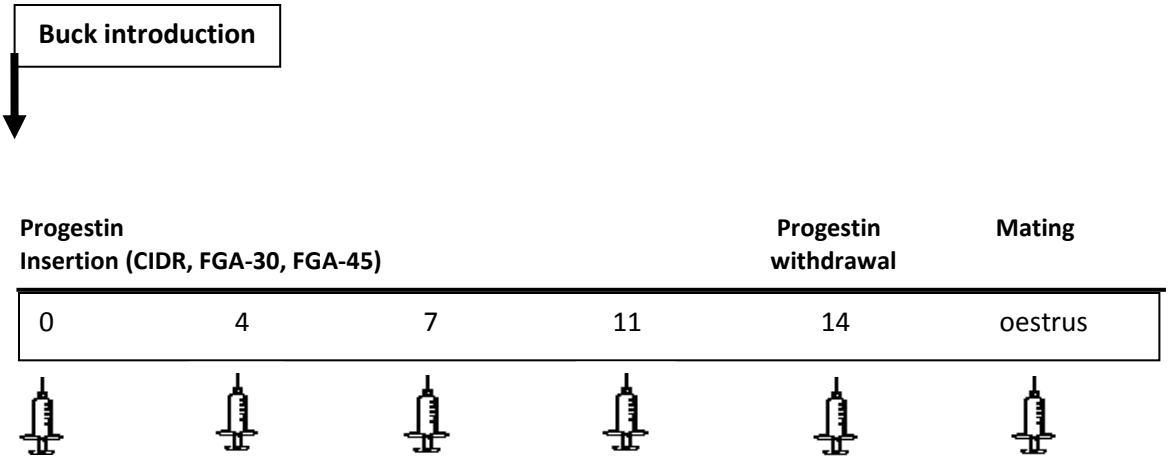


Figure 3.5: Blood sampling summary for serum progesterone profile of Red Sokoto does treated with CIDR®, FGA-30® and FGA-45® with or without continuous buck exposure.

CIDR® = Controlled internal drug release devices

FGA-30® = 30 mg fluorogestone acetate sponges

FGA-45® = 45 mg fluorogestone acetate sponges

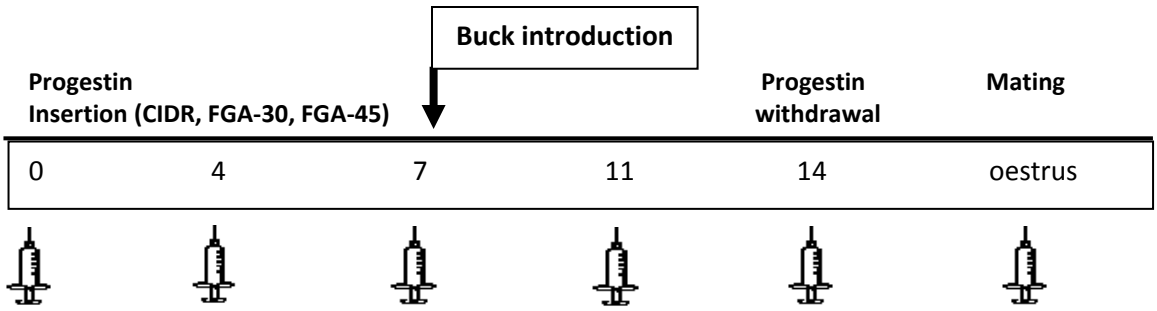


Figure 3.6: Blood sampling summary to evaluate serum progesterone profile of Sahel does treated with CIDR®, FGA-30® and FGA-45® with or without aproned buck exposure.

CIDR® = Controlled internal drug release devices

FGA-30® = 30 mg fluorogestone acetate sponges

FGA-45® = 45 mg fluorogestone acetate sponges

3.6 Oestrus Detection and Breeding

Does were monitored daily from the start of the experiment for oestrus behaviour and receptivity in the morning (0800 h – 1000 h) and in the evening (1500 h – 1700 h) for 19 days as illustrated (Figure 3.1). A doe was considered to be in oestrus if it allowed mounting by the aproned buck and breeding on standing oestrus.

3.7 Sample Collection and Hormonal Asssay

Five (5) milliliters of blood were collected at 08:00 hours by jugular-venipuncture into sterile plain bottles using a 10-ml hypodermic syringe, fitted with 21 gauge needle on days 0 (before insertion of progestagens with or without buck exposure), 4, 7, 11, 14 (day of progestagens withdrawal) and oestrus. Blood samples were allowed to clot, quickly transported to the laboratory and stored at +4 ^{o}C for 24 hours. Thereafter, serum samples were separated by centrifugation at 2500 x g for 15 minutes, placed in appropriately labeled serum vials and stored at -20˚C until analyses. Concentration of progesterone was measured in serum using competitive immune-enzymatic colorimetric method for quantitative determination of progesterone. It was based on the principle of solid phase enzyme-linked immunosorbent assay (ELISA). The ELISA kits were used according to the manufacturer's specifications (Appendix III).

3.8 Data Collection and Analyses

Oestrus response rate (%) was described as the number of does showing standing oestrus and subsequently mated over the total number of does in each treatment group, expressed in percentage. Time to onset of oestrus (TOO) was considered to be the time interval from

withdrawal of progestagen or teasing (d 14) to the time when a doe stood to be mounted. Duration of oestrus (DOO) was considered to be the time between the first and last standing oestrus, expressed as the mean ± standard error of mean (SEM). Mounts per oestrus period (MPOP) was defined as the number of successful mounts during the induced oestrus period, expressed as mean ± standard error of mean (SEM). Conception rate was determined using measurement of non-return rate of oestrus 19 – 21 days following natural mating. Pregnancy rate was determined by total number of does pregnant, divided by the total number of does treated in each group. Kidding rate (%) was evaluated as the number of does that kidded, divided by the number of does mated and expressed as percentage. Variables such as oestrus response, conception, pregnancy and kidding rates were presented using descriptive statistics. Data on serum levels, MPOP, TOO and DOO were expressed as mean ± S.E.M. One-way analysis of variance (ANOVA) and post-hoc Tukey's test was used to compare means of TOO, DOO and MPOP within and among treatments. Student's t-test was used to compare between similar treatments in the dry and rainy season. Chi-square was used to test for association between treatments on oestrus response, conception, pregnancy and kidding rates. GraphPad Prism® version 5.01 (2009) data package for Windows from GraphPad Software, San Deigo, California, USA (www.graphpad.com) was employed for all statistical analyses. Values of $P < 0.05$ were considered significant.

CHAPTER FOUR

4.0 RESULTS

4.1 Meteorological conditions

The meteorological conditions during the study period are presented in Table 4.1. Mean relative humidity (RH) was 19 % and 68 % in the dry and rainy seasons, respecrively. Mean ambient temperature (AT) was 26 ^{o}C and 27 ^{o}C in the dry and rainy seasons, respectively. Wind speed was higher in the rainy than in the dry season, while evaporation was lower in the rainy season. The dry season was characterised by a total lack of rainfall, while 334 mm was obtained for the rainy season (Table 4.1).

Mean body condition score of Red Sokoto does was higher ($P < 0.05$) in the rainy season (3.3 ± 0.2 kg) than in the dry season (2.8 ± 0.1 kg). Similarly, mean body weight was higher ($P < 0.05$) in the rainy (26.83 ± 0.36 kg) than in the dry season (21.56 ± 0.62 kg). Mean body condition score of Sahel does was higher ($P < 0.05$) in the rainy season (2.9 ± 0.1 kg) than in the dry season (2.4 ± 0.1 kg). Similarly, mean body weight was higher ($P < 0.05$) in the rainy (24.21 ± 0.37 kg) than in the dry season (19.03 ± 0.11 kg).

Table 4.1: Meteorological conditions from the study period during the dry and rainy seasons in Zaria.

		Meteorological conditions					
Season	Months	RH (%)	AT (^{0}C)	WS (km/day)	SD (h)	EV (mm)	RF (mm)
DS	Nov – Apr	18.9 ± 3.8[a] (20.5 ± 4.8 - 17.3 ± 2.7)	26.4 ± 1.4[a] (34.9 ± 1.4 - 17.9 ± 1.3)	148.8 ± 14.9[a]	7.6 ± 0.3[a]	10.8 ± 1.6[a]	0.00
RS	May – Oct	68.2 ± 3.9[b] (74.6 ± 3.4 - 61.7 ± 4.4)	27.1 ± 1.3[a] (34.1 ± 2.1 - 20.1 ± 0.5)	156.4 ± 15.3[a]	6.1 ± 0.3[b]	6.7 ± 0.8[b]	334.9

RH = Relative humidity AT = Ambient temperature WS = Wind speed SD = Sunshine duration EV = Evaporation
RF = Rainfall mm = Millimeters h = hours ^{0}C = Degree Celsius (%) = Percentage
Min = Minimum Max = Maximum DS = Dry season RS = Rainy season

*Source: Data collected from the Department of Soil Science, Institute for Agricultural Research, Ahmadu Bello University, Zaria

[a,b] = Means with different superscript letters along the same columns differ significantly ($P < 0.05$)

Values in parenthesis are maximum - minimum

4.2 Oestrus response of Red Sokoto does treated with continuous buck exposure and CIDR in the dry and rainy seasons

The oestrus response of RS does following different treatments in the dry and rainy seasons are shown in Table 4.2. Oestrus response did not differ significantly between treatments in the dry and rainy seasons. However, it was higher in the buck-exposed groups (BE, BECD) than in the non-exposed does (CD, CN) in both the dry and rainy seasons. Furthermore, oestrus response was higher in the CIDR treated does (BECD, CD) than in the non-CIDR treated does (BE, CN) in the rainy season. Generally, oestrus response was similar and did not differ in the dry and rainy seasons (Table 4.1). Cumulative oestrus response for the BECD does was highest in both the dry and rainy season. On the other hand, lowest cumulative oestrus response was observed in the CN does both in the dry and rainy seasons (Figure 4.1). Average oestrus occurrence was higher in the morning (08:00-10:00 h) than in the evening (16:00-18:00 h) in the dry and rainy season (Figure 4.2).

Table 4.2: Oestrus response of Red Sokoto does treated with continuous buck exposure and CIDR in the dry and rainy seasons

	Dry Season		Rainy Season	
Treatment groups	n	Does in oestrus (%)	n	Does in oestrus (%)
Exposure and progestagens				
Buck exposure and no CIDR treatment	28	25 (89.3)	22	19 (86.4)
Buck exposure and CIDR treatment	28	24 (85.7)	22	20 (90.9)
No exposure and CIDR treatment	20	13 (65.0)	20	14 (70.0)
No exposure and no CIDR treatment	20	8 (40.0)	20	6 (30.0)
Exposure				
Buck exposure (pooled)	56	49 (87.5)	44	39 (88.6)
No exposure (pooled)	40	21 (52.5)	40	20 (50.0)
Progestagen				
CIDR treatment (pooled)	48	37 (70.1)	42	34 (80.9)
No CIDR treatment (pooled)	48	33 (68.8)	42	25 (59.5)
Oestrus response (pooled)	96	70 (72.9)	84	59 (70.0)

n = number of does treated (%) = Percent CIDR = Controlled internal drug release device

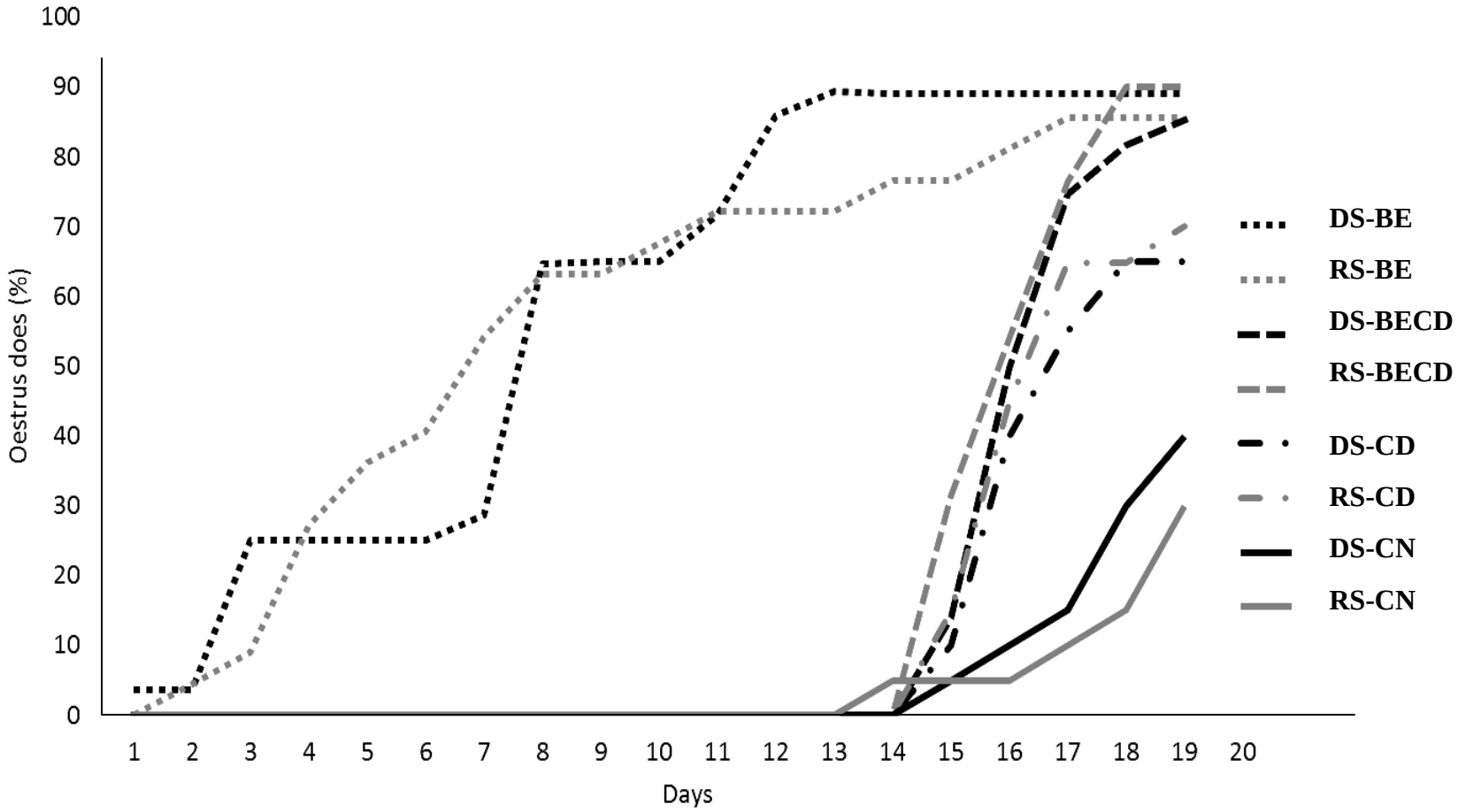


Figure 4.1: Cummulative frequency of oestrus observed over a 19-day period in Red Sokoto does treated with continuous buck exposure and CIDR in the dry and rainy seasons.

BE = Buck exposed only BECD = Buck exposure + CIDR treatment CD = CIDR only CN = Control

RS = Rainy season DS = Dry season

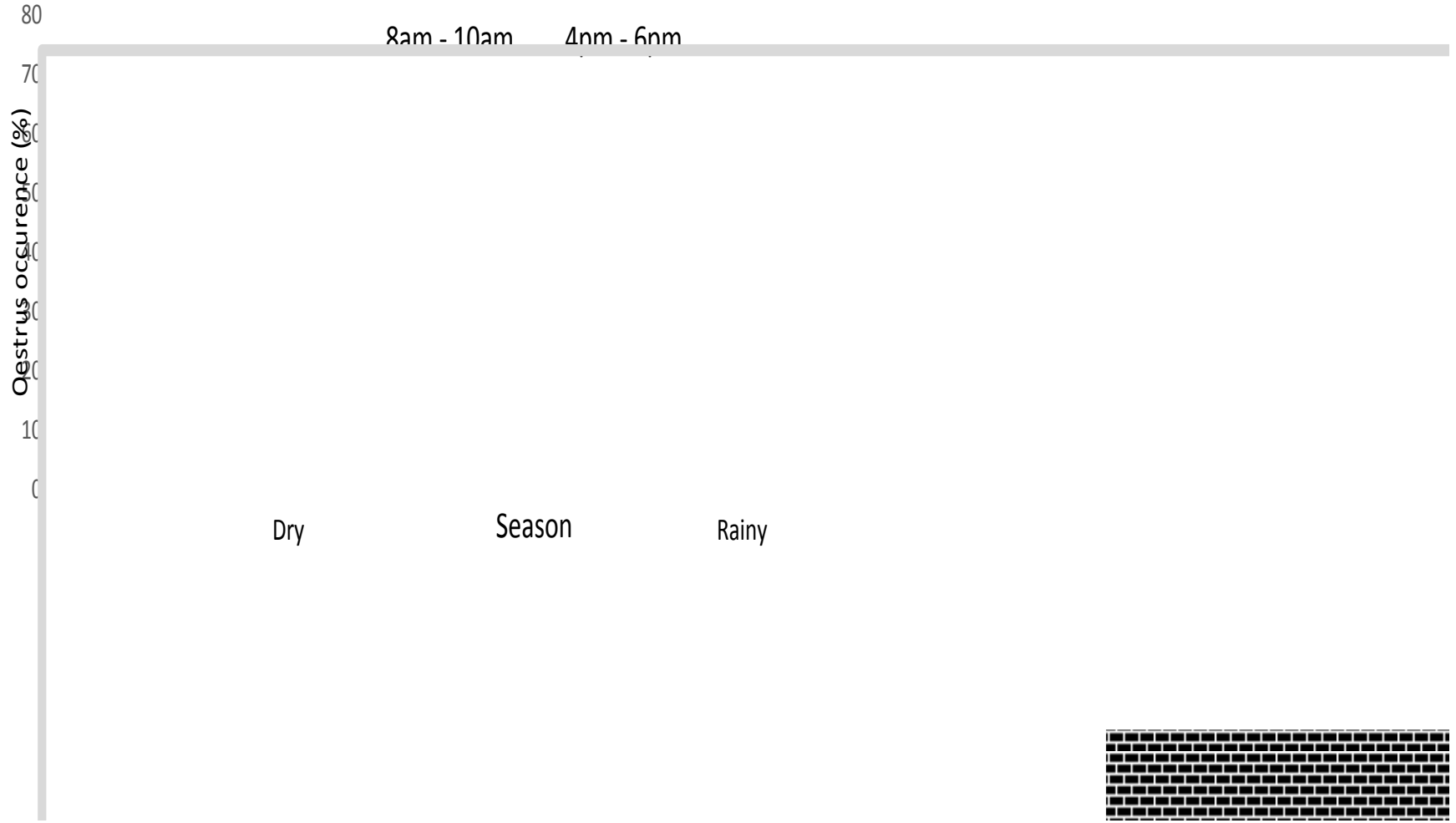


Figure 4.2: Period of oestrus occurrence observed over a 19-day period in Red Sokoto does treated with continuous buck exposure and CIDR in the dry and rainy season.

4.3 Interval to onset of oestrus of Red Sokoto does treated with continuous buck exposure and CIDR in the dry and rainy season.

The interval to onset of oestrus of RS does treated with CIDR and exposed to buck are shown in Table 4.3. A longer ($P < 0.05$) interval to oestrus was observed in does exposed to bucks only, compared to does treated with CIDR and exposed to bucks in both dry and rainy seasons (Table 4.3). The BECD does were in oestrus at 23.5 h in the dry season, significantly ($P < 0.05$) shorter than the 41.7 h observed in the rainy season. The CIDR treated does (BECD, CD) were in oestrus earlier ($P < 0.05$) than the non-CIDR treated does (BE, CN) (Table 4.3).

Table 4.3: Interval to onset of oestrus of Red Sokoto does treated with continuous buck exposure and CIDR in the dry and rainy seasons.

Treatment groups	Dry Season		Rainy Season	
	n	Time to onset of oestrus (h)	n	Time to onset of oestrus (h)
Exposure and progestagens				
Buck exposure + no CIDR treatment	25	$123.9 \pm 9.9^{a*}$	19	$133.6 \pm 16.4^{a*}$
Buck exposure + CIDR treatment	24	23.5 ± 0.1^{b}	20	$41.7 \pm 4.0^{b*}$
No exposure + CIDR treatment	13	$38.1 \pm 3.2^{b,c*}$	14	$35.1 \pm 4.7^{b,c*}$
No exposure + no CIDR treatment	8	$70.6 \pm 10.3^{b,d*}$	6	$92.9 \pm 14.5^{a,b,d*}$
Exposure				
Buck exposure (pooled)	49	73.7 ± 5^{a}	39	87.7 ± 10.2^{a}
No exposure (pooled)	21	54.4 ± 6.8^{b}	20	64.1 ± 9.6^{b}
Progestagen				
CIDR treatment (pooled)	37	30.8 ± 1.7^{a}	34	38.4 ± 4.4^{a}
No CIDR treatment (pooled)	33	97.3 ± 10.1^{b}	25	113.4 ± 15.5^{b}
Time to onset of oestrus (pooled)	96	$64.1 \pm 5.9^{*}$	84	$75.8 \pm 9.9^{*}$

^{a,b,c,d} Data (Mean ± SEM) in columns with different superscript letter are significantly ($P < 0.05$) different.
$^{*,\#}$ Data (Mean ± SEM) in rows across seasons with different superscripts are significantly ($P<0.05$) different.

4.4 Duration of oestrus of Red Sokoto does treated with continuous buck exposure and CIDR in the dry and rainy season.

The duration of oestrus of Red Sokoto does treated with progestagens and buck exposure in the dry and rainy season are shown in Table 4.4. A longer ($P < 0.05$) duration of oestrus was observed in does exposed to bucks only, compared to does treated with CIDR and exposed to bucks in dry season (Table 3.4). The BECD does had a longer ($P < 0.05$) oestrus duration than the CD does, both in the dry and rainy seasons. Generally, oestrus duration was longer in does exposed to buck (BECD, BE) than does without buck exposure in the dry and rainy seasons (Table 4.4).

Table 4.4: Duration of oestrus in Red Sokoto does treated with continuous buck exposure and CIDR in the dry and rainy season

Treatment groups	Dry Season		Rainy Season	
	n	Duration of oestrus (h)	n	Duration of oestrus (h)
Exposure and progestagens				
Buck exposure + no CIDR treatment	25	$55.7 \pm 3.5^{a*}$	19	$26.3 \pm 0.1^{a\#}$
Buck exposure + CIDR treatment	24	$38.4 \pm 5.3^{b*}$	20	$46.7 \pm 0.8^{b*}$
No exposure + CIDR treatment	13	$33.2 \pm 3.6^{b*}$	14	$32.4 \pm 1.5^{a*}$
No exposure + no CIDR treatment	8	$32.4 \pm 1.0^{b*}$	6	$29.4 \pm 3.7^{a*}$
Exposure				
Buck exposure (pooled)	49	$47.05 \pm 4.4^{a*}$	39	$36.5 \pm 0.5^{a*}$
No exposure (pooled)	21	$32.8 \pm 2.3^{b*}$	20	$30.9 \pm 2.6^{a*}$
Progestagen				
CIDR treatment (pooled)	37	$35.8 \pm 4.5^{a*}$	34	$39.6 \pm 1.2^{a*}$
No CIDR treatment (pooled)	33	$44.1 \pm 2.3^{b*}$	25	$27.9 \pm 1.9^{b\#}$
Duration of oestrus (pooled)	96	$39.9 \pm 3.4^{*}$	84	$33.7 \pm 1.5^{*}$

^{a,b} Data (Mean ± SEM) in columns with different superscript letters are significantly ($P < 0.05$) different.
$^{*,\#}$ Data (Mean ± SEM) in rows across seasons with different superscripts are significantly ($P<0.05$) different.

4.5 Mounts per oestrus period of Red Sokoto does treated with continuous buck exposure and CIDR in the dry and rainy season.

The mounts per oestrus period of RS does treated with CIDR and exposure to buck are shown in Table 4.5. Averagely, higher ($P < 0.05$) mounts per oestrus period was observed in the buck exposed does compared to the non-exposed in the dry and rainy seasons (Table 4.5). The BECD does exhibited higher ($P < 0.05$) mounts per oestrus period in the rainy season than the dry season. The lowest number of mounts per oestrus period was recorded in the CN does in the dry and rainy seasons (Table 4.5).

Table 4.5: Mounts per oestrus period of Red Sokoto does treated with continuous buck exposure and CIDR in the dry and rainy seasons

Treatment groups	Dry Season		Rainy Season	
	n	Mounts per oestrus period	n	Mounts per oestrus period
Exposure and progestagens				
Buck exposure + no CIDR treatment	25	$5.4 \pm 0.4^{a*}$	19	$4.1 \pm 0.4^{a\#}$
Buck exposure + CIDR treatment	24	$4.1 \pm 0.3^{b*}$	20	$5.5 \pm 0.2^{b\#}$
No exposure + CIDR treatment	13	$2.6 \pm 0.2^{c,d*}$	14	$3.6 \pm 0.2^{a,d*}$
No exposure + no CIDR treatment	8	$2.4 \pm 0.3^{b,c,d*}$	6	$1.7 \pm 0.3^{c,d,e*}$
Exposure				
Buck exposure (pooled)	49	$4.8 \pm 0.4^{a*}$	39	$4.8 \pm 0.3^{a*}$
No exposure (pooled)	21	$2.5 \pm 0.3^{b*}$	20	$2.7 \pm 0.3^{b*}$
Progestagen				
CIDR treatment (pooled)	37	$3.4 \pm 0.3^{a*}$	34	$4.6 \pm 0.2^{a\#}$
No CIDR treatment (pooled)	33	$3.9 \pm 0.4^{a*}$	25	$2.9 \pm 0.4^{b\#}$
Mounts per oestrus period (pooled)	96	3.6 ± 0.3*	84	3.7 ± 0.3*

^{a,b,c,d,e} = Data (Mean ± SEM) in columns with different superscript letters are significantly ($P < 0.05$) different.
$^{*,\#}$ = Data (Mean ± SEM) in rows across seasons with different superscripts are significantly ($P<0.05$) different .

4.6 Conception, pregnancy and kidding rates of Red Sokoto does treated with continuous buck exposure and CIDR in the dry and rainy seasons.

The conception, pregnancy and kidding rates of RS does treated with progestagens and continuous exposure to bucks in the dry and rainy season are shown in Table 4.6. Higher conception was observed in the BECD does, compared to the CD does. Similarly, does exposed to the buck effect showed higher conception than does not exposed to bucks. Overall, conception rates were higher in all treatments in the rainy season than in the dry season (Table 4.6). Pregnancy rates were higher in the rainy season than dry season (Table 4.6). However, lower pregnancy rates were observed in the non-exposed does (CD, CN), compared to the buck exposed does (BECD, BE).

Table 4.6: Conception, pregnancy and kidding rates of Red Sokoto does treated with continuous buck exposure and CIDR in the dry and rainy seasons.

Treatment groups	Dry Season					Rainy Season				
	Does treated n	Does bred n	CR n (%)	PR %	KR %	Does treated n	Does bred n	CR n (%)	PR %	KR %
Exposure and progestagens										
Buck exposure + no CIDR	28	25	22 (88.0)	78.6	80.0	22	19	18 (94.7)	81.8	50.0
Buck exposure + CIDR	28	24	19 (79.2)	67.9	96.0	22	20	20 (100)	90.9	54.0
No exposure + CIDR	20	13	8 (61.5)	40.0	77.0	20	14	11 (78.6)	55.0	100
No exposure + no CIDR	20	8	7 (87.5)	35	62.0	20	6	6 (100)	30.0	83.0
Exposure										
Buck exposure (pooled)	56	49	41 (83.7)	73.2	88.0	44	39	38 (97.4)	86.4	52.0
No exposure (pooled)	40	21	15 (71.4)	37.5	70.0	40	20	17 (85.0)	42.5	100
Progestagen										
CIDR treatment (pooled)	48	37	27 (72.9)	56.3	87.0	42	34	31 (91.2)	73.8	92.0
No CIDR treatment (pooled)	48	33	29 (87.9)	60.4	71.0	42	25	24 (96)	57.1	67.0
Total (pooled)	96	70	56 (80.0)	58.3	79.0	84	59	55 (93.2)	65.5	79.0

CR = Conception rate PR = Pregnancy rate KR = Kidding rate % = Percentage n = Number

CIDR = Controlled Internal Drug Release Device

4.7 Oestrus response of Sahel does treated with progestagens and 7-day buck stimulus in the dry and rainy season.

The oestrus response of SH does following different treatments in the dry and rainy season are shown in Table 4.7. Overall oestrus response did not differ significantly between treatments in the dry (48.9 %) and rainy (59.2 %) season. However, oestrus response was higher ($P < 0.05$) in the buck-exposed does (BE, BECD) than in the non-exposed does (CD, CN) in both dry and rainy seasons. Furthermore, oestrus response was higher ($P < 0.05$) in the CIDR treated does (BECD, CD) than in the non-CIDR treated does (BE, NBENCD) in the dry and rainy seasons. Cumulative oestrus response for the BECD does was highest within the 5-day breeding period after CIDR withdrawal in both the dry and rainy seasons (Figure 4.3). The lowest cumulative oestrus response was observed in the CN does in both the dry and rainy seasons (Table 4.7). Average oestrus occurrence was higher in the morning (08:00-10:00 h) than in the evening (16:00-18:00 h) hours in the dry and rainy seasons (Figure 4.3).

Table 4.7: Oestrus response of Sahel does treated with progestagens and exposed to buck for seven days in the dry and rainy season.

	Dry Season		Rainy Season	
Treatment groups	n	Does in oestrus (%)	n	Does in oestrus (%)
Exposure and progestagens				
Buck exposure + no CIDR treatment	22	10 (45.5)	30	18 (60.0)
Buck exposure + CIDR treatment	25	17 (68.0)	30	23 (76.7)
No exposure + CIDR treatment	25	13 (52.0)	30	20 (66.7)
No exposure + no CIDR treatment	22	6 (27.3)	30	10 (33.3)
Exposure				
Buck exposure (pooled)	47	27 (57.4)	60	41 (68.3)
No exposure (pooled)	47	19 (40.4)	60	30 (50.0)
Progestagen				
CIDR treatment (pooled)	50	30 (60.0)	60	43 (71.7)
No CIDR treatment (pooled)	44	16 (36.4)	60	28 (46.7)
Oestrus response (pooled)	94	46 (48.9)	120	71 (59.2)

n = number of does treated (%) = Percentage CIDR = Controlled internal drug release device

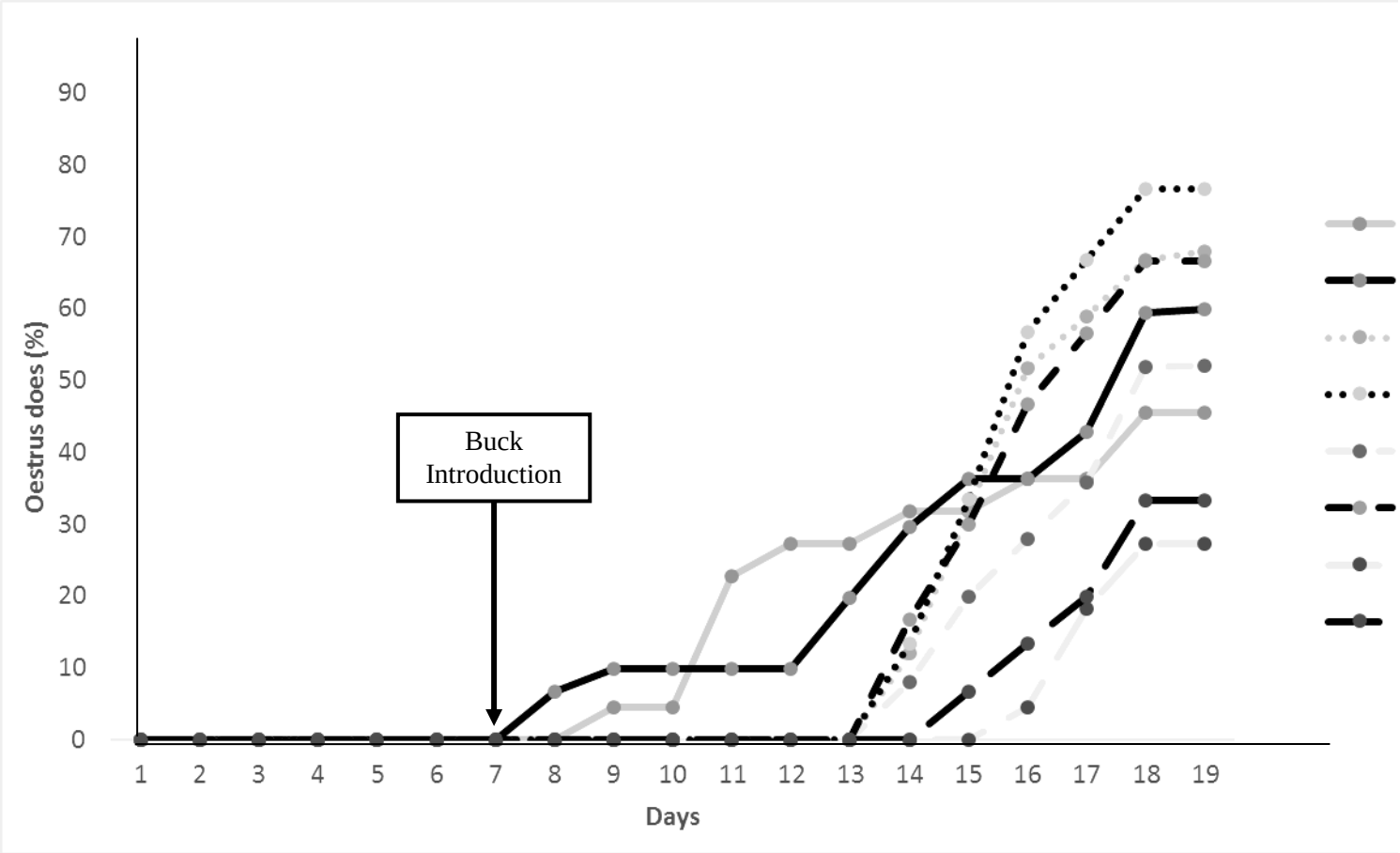


Figure 4.3: Cumulative frequency of oestrus observed over a 19-day period in Sahel does treated with CIDR and buck exposure in the dry and rainy seasons.

BE = Buck exposure BECD = Buck exposure + CIDR treatment CD = CIDR treatment only CN = Control

DS = Dry season RS = Rainy season

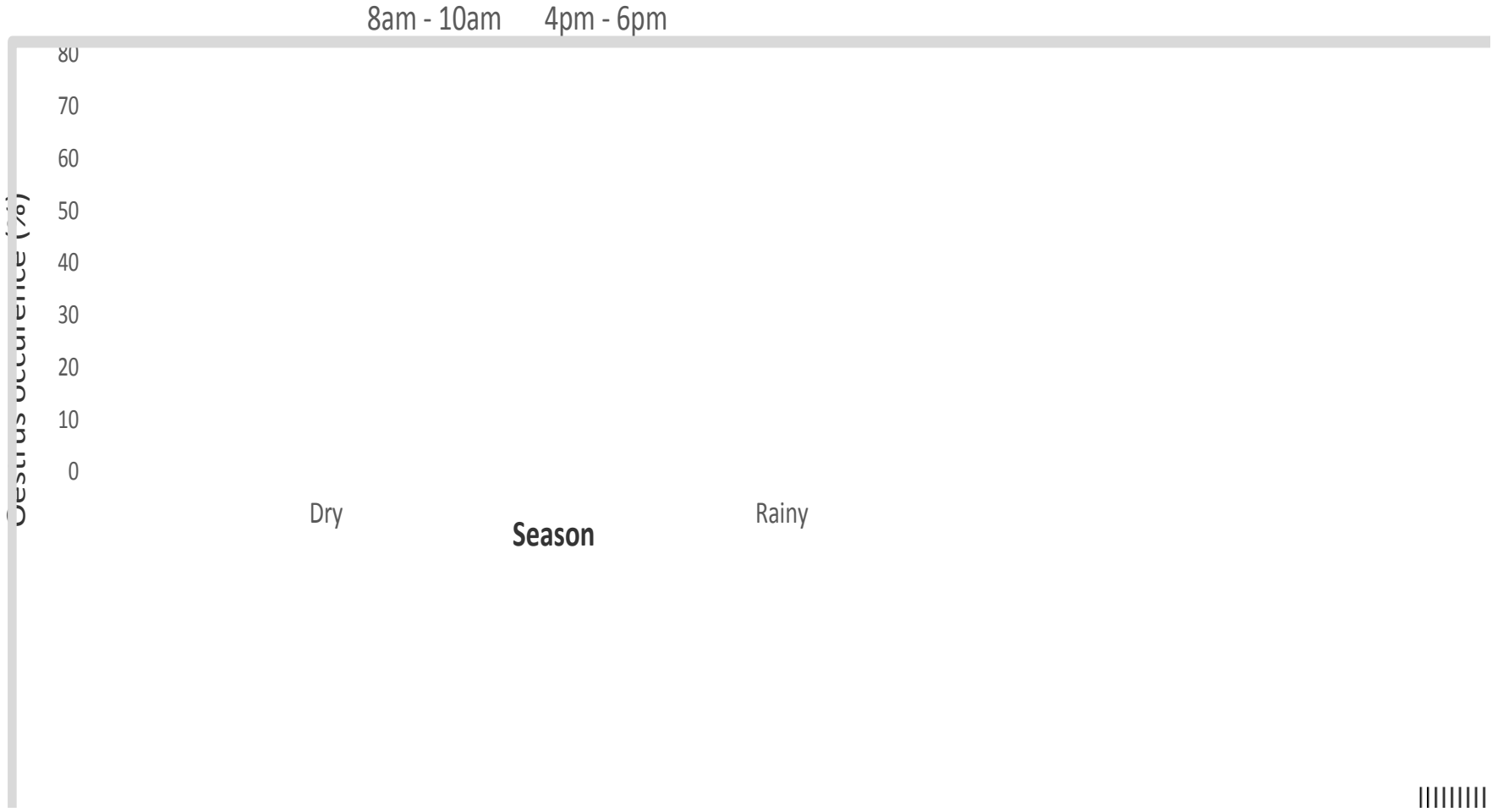


Figure 4.4: Period of oestrus occurrence observed over a 19-day period in Sahel does treated with CIDR and buck exposure in the dry and rainy seasons.

CIDR = Controlled internal drug release devices

4.8 Interval to onset of oestrus of Sahel does treated with progestagens and 7-day buck exposure in the dry and rainy season.

The interval to onset of oestrus of SH does treated with CIDR with or without exposure to buck are shown in Table 4.8. A longer ($P < 0.05$) interval to oestrus was observed in does exposed to bucks, compared to does treated with CIDR and exposed to bucks in both dry and rainy seasons (Table 4.8). The BECD does were in oestrus at 29.2 h in the dry season, comparable to the 29.5 h observed in the rainy season. Also, CIDR treated does (BECD, CD) were in oestrus faster ($P < 0.05$) than the non-CIDR treated does (BE, CN). The CD does were in oestrus at 36.7 h in the dry season, significantly ($P<0.05$) longer than the 28.6 h recorded for them in the rainy season (Table 4.7).

Table 4.8: Interval to onset of oestrus in Sahel does treated with progestagens and 7-day buck exposure in the dry and rainy season

Treatment groups	Dry Season n	Dry Season Time to onset of oestrus (h)	Rainy Season n	Rainy Season Time to onset of oestrus
Exposure and progestagens				
Buck exposure + no CIDR treatment	10	94.3 ± 11.3[a*]	18	71.9 ± 11.9[a*]
Buck exposure + CIDR treatment	17	29.2 ± 1.9[b*]	23	29.5 ± 2.1[b*]
No exposure + CIDR treatment	13	36.7 ± 3.1[b,c*]	20	28.6 ± 2.7[c,b*]
No exposure + no CIDR treatment	6	69.7 ± 11.4[a,c,d*]	10	61.2 ± 8.5[a,c,d*]
Exposure				
Buck exposure (pooled)	27	61.8 ± 6.6[a]	41	50.7 ± 7.0[a]
No exposure (pooled)	19	53.2 ± 7.3[a]	30	44.9 ± 5.6[a]
Progestagen				
CIDR treatment (pooled)	30	32.9 ± 2.5[a*]	43	29.1 ± 2.4[a*]
No CIDR treatment (pooled)	16	82.0 ± 11.4[b*]	28	66.6 ± 10.2[b#]
Time to onset of oestrus (pooled)	46	57.5 ± 6.9[*]	71	47.8 ± 6.3[*]

[a,b,c,d] Data (Mean ± SEM) in columns with different superscript letter are significantly ($P < 0.05$) different
[*,#] Data (Mean ± SEM) in rows across seasons with different superscripts are significantly ($P<0.05$) different

4.9 Duration of oestrus of Sahel does treated with progestagens and exposed to buck in the dry and rainy seasons.

The duration of oestrus in SH does treated with progestagens and subjected to buck exposure in the dry and rainy seasons are shown in Table 4.9. Overall, duration of induced oestrus did not differ significantly between groups (Table 4.9), but the mean oestrus duration was longer ($P < 0.05$) in the CIDR-treated does than in the non-CIDR treated does. Average duration of oestrus was longer in the rainy (31.9 h) compared to the dry (28.9 h) season.

Table 4.9: Duration of oestrus in Sahel does treated with progestagens and buck exposure in the dry and rainy season

Treatment groups	Dry Season		Rainy Season	
	n	Duration of oestrus (h)	n	Duration of oestrus
Exposure and progestagens				
Buck exposure + no CIDR treatment	10	26.1 ± 1.3[a*]	18	31.4 ± 2.5[a*]
Buck exposure + CIDR treatment	17	31.5 ± 1.2[a*]	23	32.0 ± 1.2[a*]
No exposure + CIDR treatment	13	36.8 ± 0.7[a,b*]	20	32.5 ± 3.3[a*]
No exposure + no CIDR treatment	6	21.2 ± 2.5[a*]	10	31.5 ± 2.7[a#]
Exposure				
Buck exposure (pooled)	27	28.8 ± 1.3[a*]	41	31.7 ± 1.9[a*]
No exposure (pooled)	19	29.0 ± 1.6[a*]	30	32.0 ± 3.0[a*]
Progestagen				
CIDR treatment (pooled)	30	34.2 ± 0.9[a*]	43	32.3 ± 2.3[a*]
No CIDR treatment (pooled)	16	23.7 ± 1.9[b*]	28	31.5 ± 2.6[a#]
Duration of oestrus (pooled)	46	28.9 ± 1.4[*]	71	31.9 ± 2.4[*]

[a,b] Data (Mean ± SEM) in columns with different superscript letters are significantly ($P < 0.05$) different
[*,#] Data (Mean ± SEM) in rows across seasons with different superscripts are significantly ($P<0.05$) different

4.10 Mounts per oestrus period of Sahel does treated with progestagens and buck exposure in the dry and rainy seasons.

The mounts per oestrus period of Sahel does treated with CIDR and exposed to buck are shown in Table 4.10. Averagely, higher ($P < 0.05$) mounts per oestrus period was observed in does exposed to bucks, compared to does not exposed to buck in the dry season only (Table 4.10). BECD does had higher ($P < 0.05$) mounts per oestrus period than CD does in the dry season. Mounts per oestrus period did not differ between treatments in the rainy season (Table 4.10). The lowest number of mounts per oestrus period was recorded in the CN does in the dry season (Table 4.10).

Table 4.10: Mounts per oestrus period of Sahel does treated with progestagens and buck exposure in the dry and rainy season

Treatment groups	Dry Season		Rainy Season	
	n	Mounts per oestrus period	n	Mounts per oestrus period
Exposure and progestagens				
Buck exposure + no CIDR treatment	10	$2.3 \pm 0.2^{a*}$	18	$3.6 \pm 0.2^{a\#}$
Buck exposure + CIDR treatment	17	$5.1 \pm 0.4^{b*}$	23	$3.7 \pm 0.3^{a\#}$
No exposure + CIDR treatment	13	$3.2 \pm 0.3^{a,c*}$	20	$3.7 \pm 0.2^{a*}$
No exposure + no CIDR treatment	6	$2.2 \pm 0.2^{a,c,d*}$	10	$3.9 \pm 0.1^{a\#}$
Exposure				
Buck exposure (pooled)	27	$3.7 \pm 0.3^{a*}$	41	$3.7 \pm 0.3^{a*}$
No exposure (pooled)	19	$2.7 \pm 0.3^{b*}$	30	$3.8 \pm 0.2^{a\#}$
Progestagen				
CIDR treatment (pooled)	30	$4.2 \pm 0.4^{a*}$	43	$3.7 \pm 0.3^{a*}$
No CIDR treatment (pooled)	16	$2.3 \pm 0.2^{b*}$	28	$3.8 \pm 0.2^{a\#}$
Mounts per oestrus period (pooled)	46	$3.2 \pm 0.3^{*}$	71	$3.7 \pm 0.2^{*}$

^{a,b,c,d} Data (Mean ± SEM) in columns with different superscript letters are significantly ($P < 0.05$) different
$^{*,\#}$ Data (Mean ± SEM) in rows across seasons with different superscripts are significantly ($P<0.05$) different
CIDR = Controlled internal drug release devices

4.11 Conception, pregnancy and kidding rates of Sahel does treated with progestagens and exposed to buck in the dry and rainy seasons.

The conception, pregnancy and kidding rates of SH does treated with progestagens and exposed to bucks in the dry and rainy seasons are presented in Table 4.11. Highest conception was observed in the BE does compared to the CD does in the dry and rainy season (Table 4.11). Averagely, does exposed to the buck effect showed higher conception than does not exposed to bucks although not significantly. Overall, conception rates were higher in the rainy season (88.7 %) than dry season (80.4 %) (Table 4.11). Pregnancy rates were lower ($P < 0.05$) in the non-buck exposed does (CD, CN), compared to the buck exposed does (BECD, BE).

Table 4.11: Conception, pregnancy and kidding rates of Sahel does treated with progestagens and buck exposure in the dry and rainy season.

Treatment groups	Dry Season					Rainy Season				
	Does treated n	Does bred n	CR n (%)	PR %	KR %	Does treated n	Does bred n	CR n (%)	PR %	KR %
Exposure and progestagens										
Buck exposure + no CIDR treatment	22	10	9 (90.0)	40.9	140	30	18	18 (100.0)	60.0	66.0
Buck exposure + CIDR treatment	25	17	14 (82.4)	56.0	76.0	30	23	19 (82.6)	63.3	48.0
No exposure + CIDR treatment	25	13	8 (61.5)	32.0	100	30	20	18 (90.0)	60.0	40.0
No exposure + no CIDR treatment	22	6	6 (100.0)	27.3	250	30	10	8 (80.0)	26.7	70.0
Exposure										
Buck exposure (pooled)	47	27	23 (85.2)	48.9	100	60	41	37 (90.2)	61.7	56.0
No exposure (pooled)	47	19	14 (73.7)	29.7	147	60	30	26 (86.7)	43.3	50.0
Progestagen										
CIDR treatment (pooled)	50	30	22 (73.3)	44.0	87.0	60	43	37 (86.1)	61.7	44.0
No CIDR treatment (pooled)	44	16	15 (93.8)	34.1	181.0	60	28	26 (92.7)	43.3	68.0
Total (Pooled)	94	46	37 (80.4)	39.4	141.6	120	71	63 (88.7)	52.5	56.0

CR = Conception rate PR = Pregnancy rate KR = Kidding rate % = Percentage n = Number
CIDR = Controlled internal drug release devices

4.12 Oestrus response of Red Sokoto does treated with progestagens and continuous buck exposure in the dry and rainy seasons.

The oestrus responses of Red Sokoto does following different treatments in the dry and rainy season are shown in Table 4.12. The responses differed significantly between similar treatments in the dry and rainy seasons. Oestrus response was higher ($P < 0.05$) in the buck exposed does (BEF3, BEF4), compared to the non-exposed does (F3, F4) in both the dry and rainy seasons. Furthermore, oestrus response was higher ($P < 0.05$) in the BEF4 does compared to the BEF3 does, irrespective of the season (Table 4.12). Generally, oestrus response was similar and did not differ ($P > 0.05$) between the F3 and F4 does in the dry season (Table 4.12). Cumulative oestrus response for the BEF3 and BEF4 does was higher compared to the F3 and F4 does both the dry and rainy season (Figure 4.5). In this study, average oestrus occurrence was higher in the mornings (08:00-10:00 h) than in the evenings (16:00-18:00 h) in the dry and rainy seasons (Figure 4.7).

Table 4.12: Oestrus response of Red Sokoto does exposed to bucks and treated with polyurethane sponges impregnated with different doses of fluorogestone acetate in the dry and rainy seasons

Treatment groups	Dry Season		Rainy Season	
	n	Does in oestrus (%)	n	Does in oestrus (%)
Exposure and progestagens				
I (Buck exposure + FGA-30 mg)	28	18 (64.3)	30	21 (70.0)
II (Buck exposure + FGA-45 mg)	28	20 (71.4)	30	27 (90.0)
III (No buck exposure + FGA-30 mg)	20	11 (55.0)	30	20 (66.7)
IV (No buck exposure + FGA-45 mg)	20	10 (50.0)	30	23 (76.7)
Exposure				
Buck exposure (pooled)	56	38 (67.9)	60	48 (80.0)
No exposure (pooled)	40	21 (52.5)	60	43 (71.7)
Progestagen				
FGA-30 mg treatments (pooled)	48	29 (60.4)	60	41 (68.3)
FGA-45 mg treatments (pooled)	48	30 (62.5)	60	50 (83.3)
Oestrus response (pooled)	96	59 (61.5)	120	91 (75.8)

n = number of does treated
FGA = Fluorogestone acetate

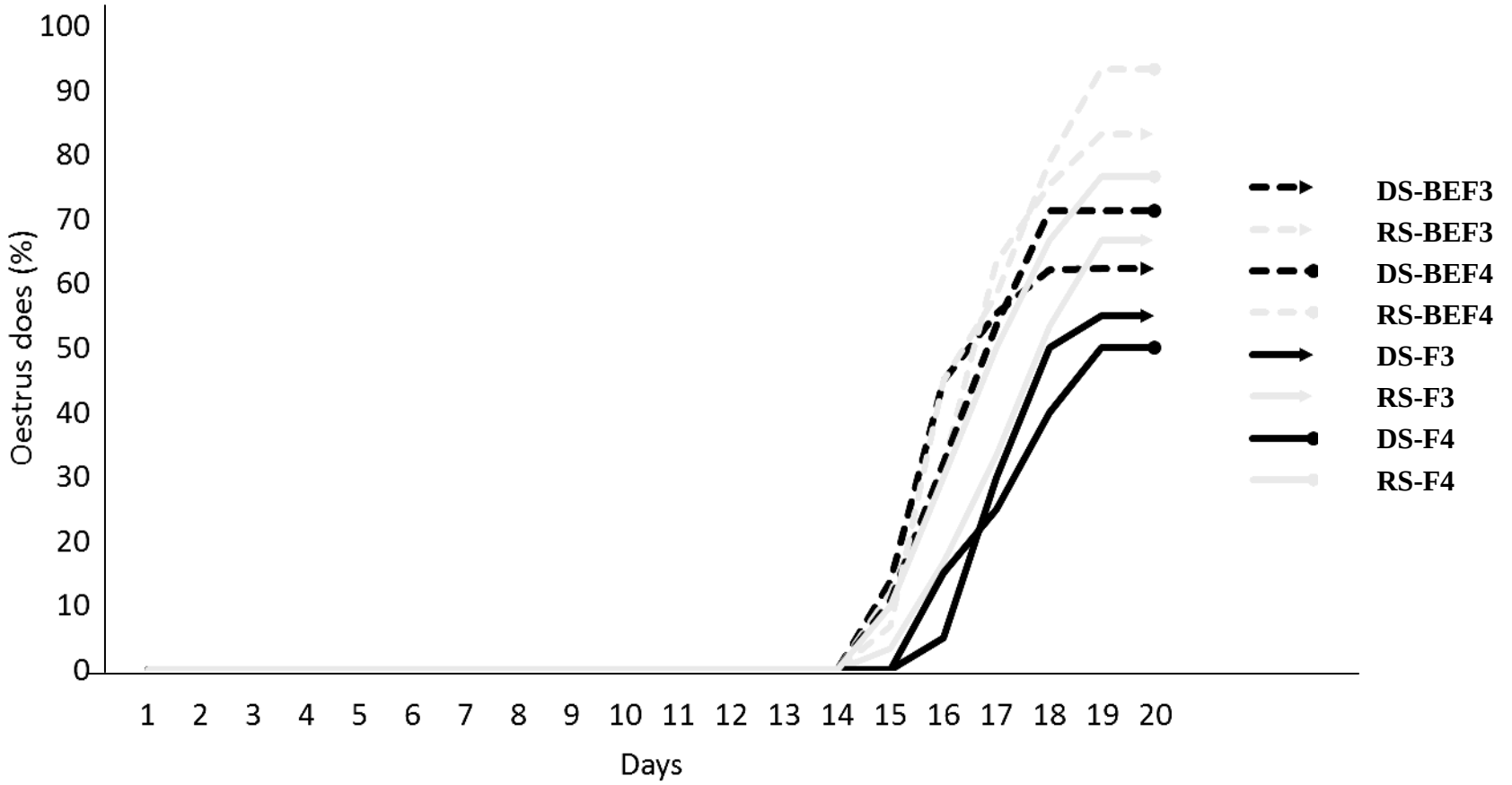


Figure 4.5: Cumulative frequency of oestrus observed over 19 days in Red Sokoto does treated with fluorogestone acetate (FGA) and buck exposure

BEF3 = Buck exposure + FGA-30 treatment F3 = FGA-30 mg DS = Dry season

BEF4 = Buck exposure + FGA-45 mg F4 = FGA-45 RS = Rainy season

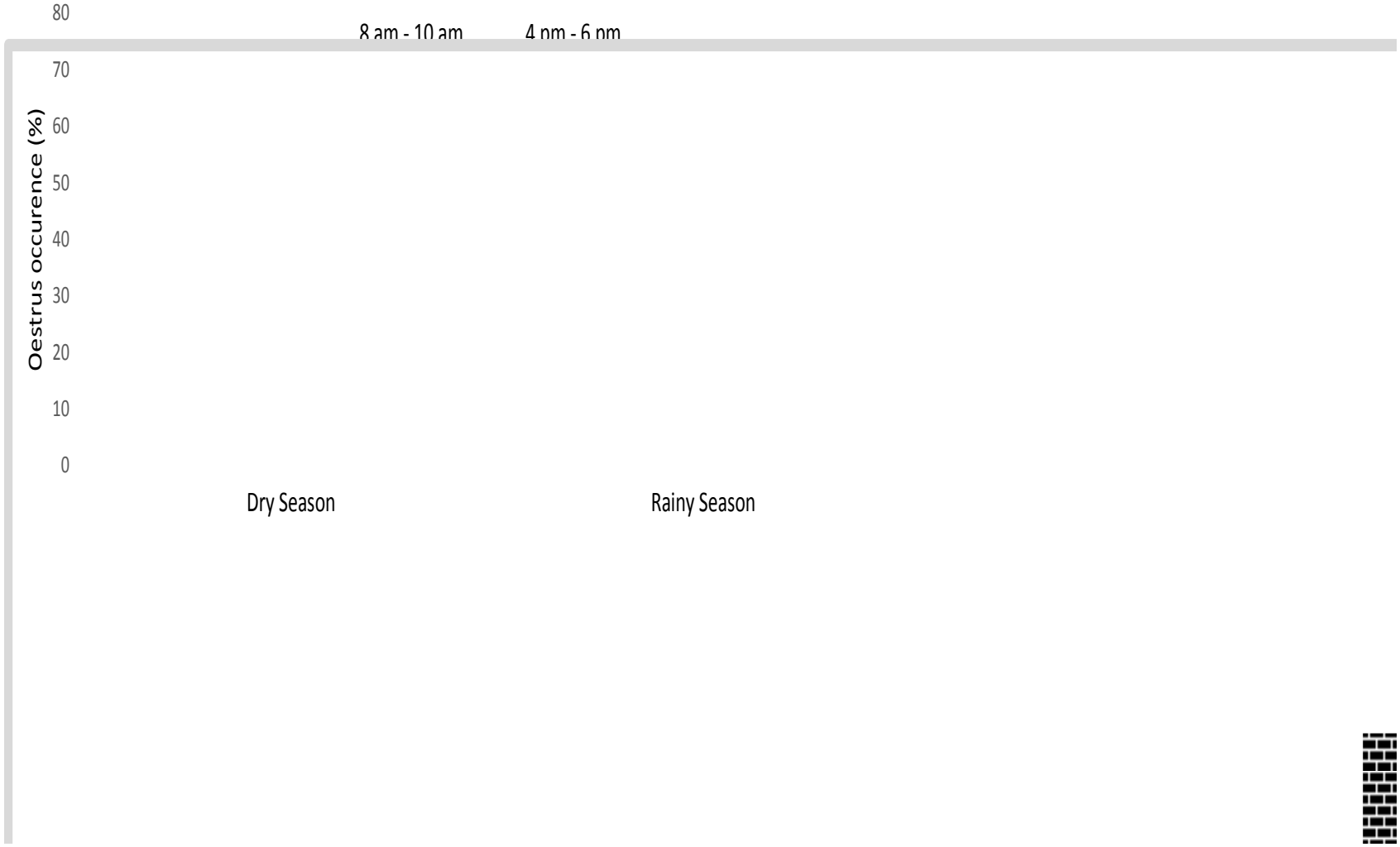


Figure 4.6: Period of oestrus occurrence observed over a 19-day period in Red Sokoto does treated with buck exposure and progestagens in the dry and rainy seasons.

4.13 Interval to onset of oestrus of Red Sokoto does treated with continuous buck exposure and fluorogestone acetate in the dry and rainy seasons

The interval to onset of oestrus of Red Sokoto does treated with FGA with or without exposure to buck are shown in Table 4.13. A longer ($P < 0.05$) interval to oestrus was observed in the F3 and F4 does, compared to the BEF3 and BEF4 does in the dry season, with the reverse in the rainy season (Table 4.13). The BEF3 does were in oestrus at 23.8 h in the dry season, significantly ($P < 0.05$) shorter than the 46.5 h obtained in the rainy season. Similarly, the BEF4 does were in oestrus at 30.3 h in the dry season, significantly ($P < 0.05$) shorter than the 38.5 h observed in the rainy season. Dose of FGA did not significantly affect time onset of oestrus in the dry season, being 30.8 h and 33.1 h for FGA-30 mg and FGA-45 mg, respectively. The time to oestrus onset was advanced ($P < 0.05$) in the F4 treatment than on the F3 treatment (Table 4.13). Generally, time to onset of oestrus was longer in the rainy (39.8 h) than dry season (31.9 h) (Table 4.13).

Table 4.13: Interval to onset of oestrus in Red Sokoto does exposed continuously to bucks and treated with polyurethane sponges impregnated with different doses of FGA in the dry and rainy seasons

Treatment groups	Dry Season		Rainy Season	
	n	Time to onset of oestrus (h)	n	Time to onset of oestrus (h)
Exposure and progestagens				
Buck exposure + FGA-30 mg	18	$23.8 \pm 1.1^{a,b,c*}$	21	$46.5 \pm 3.6^{a,b\#}$
Buck exposure + FGA- 45 mg	20	$30.3 \pm 2.0^{a*}$	27	$38.5 \pm 1.8^{a,c,d*}$
No exposure + FGA-30 mg	11	$37.8 \pm 3.4^{b,d*}$	20	$38.2 \pm 2.5^{b,d*}$
No exposure + FGA-45 mg	10	$35.9 \pm 3.8^{c,d*}$	23	$35.9 \pm 2.6^{b,c*}$
Exposure				
Buck exposure (pooled)	38	$27.1 \pm 1.6^{a*}$	48	$42.5 \pm 2.7^{a\#}$
No exposure (pooled)	21	$36.9 \pm 3.6^{b*}$	43	$37.1 \pm 2.6^{a*}$
Progestagen				
FGA-30 mg treatments (pooled)	29	$30.8 \pm 2.3^{a*}$	41	$42.4 \pm 3.1^{a\#}$
FGA-45 mg treatments (pooled)	30	$33.1 \pm 2.9^{a*}$	50	$37.2 \pm 2.2^{a*}$
Time to onset of oestrus (pooled)	59	$31.9 \pm 2.6^{*}$	91	$39.8 \pm 2.7^{*}$

^{a,b,c,d} Data (Mean ± SEM) in columns with different superscript letters are significantly ($P < 0.05$) different
$^{*,\#}$ Data (Mean ± SEM) in rows across seasons with different superscripts are significantly ($P < 0.05$) different
FGA = Flurogestone acetate

4.14 Duration of oestrus of Red Sokoto does treated with buck exposure and fluorogestone acetate in the dry and rainy seasons

The duration of oestrus in Red Sokoto does treated with fluorogestone acetate and buck exposure in the dry and rainy seasons are shown in Table 4.14. No difference ($P > 0.05$) in duration of oestrus was observed in does treated with FGA with or without exposure to bucks. Duration of induced oestrus was longer ($P < 0.05$) in the rainy season (44.5 h), compared to that of the dry season (38.7 %; Table 4.14). Duration of oestrus was longer ($P < 0.05$) in the FGA-45 mg does (42.6 h), compared to the FGA-30 mg does (34.9 h) in the dry season.

Table 4.14: Duration of oestrus in Red Sokoto does exposed to bucks and treated with polyurethane sponges impregnated with different doses of FGA in the dry and rainy seasons

	Dry Season		Rainy Season	
Treatment groups	n	Duration of oestrus (h)	n	Duration of oestrus
Exposure and progestagens				
Buck exposure + FGA-30 mg	18	32.2 ± 4.1[a*]	21	44.2 ± 0.9[a#]
Buck exposure + FGA-45 mg	20	41.4 ± 3.8[a,b*]	27	43.5 ± 0.8[a*]
No exposure + FGA-30 mg	11	37.6 ± 3.7[a,b*]	20	42.2 ± 0.8[a*]
No exposure + FGA-45 mg	10	43.7 ± 4.6[a*]	23	48.1 ± 0.6[a*]
Exposure				
Buck exposure (pooled)	38	36.8 ± 3.9[a*]	48	43.9 ± 0.9[a*]
No exposure (pooled)	21	40.7 ± 4.2[a*]	43	45.2 ± 0.7[a*]
Progestagen				
FGA-30 mg treatments (pooled)	29	34.9 ± 3.9[a*]	41	43.2 ± 0.9[a*]
FGA-45 mg treatments (pooled)	30	42.6 ± 4.2[a*]	50	45.8 ± 0.7[a*]
Duration of oestrus (pooled)	59	38.7 ± 4.1[*]	91	44.5 ± 0.8[*]

[a,b] Data (Mean ± SEM) in columns with different superscript letter are significantly ($P < 0.05$) different
[*,#] Data (Mean ± SEM) in rows across seasons with different superscripts are significantly ($P<0.05$) different
FGA = Flurogestone acetate

4.15 Mounts per oestrus period of Red Sokoto does treated with buck exposure and fluorogestone acetate in the dry and rainy seasons

The mounts per oestrus period of Red Sokoto does treated with fluorogestone acetate and exposure to buck are shown in Table 4.15 Averagely, higher ($P < 0.05$) mounts per oestrus period was observed in FGA-treated does exposed to bucks compared to does not exposed to bucks in the dry and rainy seasons (Table 4.15). The BEF3 does exhibited higher ($P < 0.05$) mounts per oestrus period in the rainy season than dry season. However, dose of FGA did not significantly influence number of mounts per oestrus period in the dry and rainy seasons. Lowest number of mounts per oestrus period was recorded in the F4 does in the dry season (Table 4.15).

Table 4.15: Mounts per oestrus period of Red Sokoto does exposed to bucks and treated with polyurethane sponges impregnated with different doses of FGA in the dry and rainy seasons

Treatment groups	Dry Season		Rainy Season	
	n	Mounts per oestrus period	n	Mounts per oestrus period
Exposure and progestagens				
Buck exposure + FGA-30 mg	25	$6.3 \pm 0.3^{a*}$	19	$7.1 \pm 0.3^{a,b,e*}$
Buck exposure + FGA-45 mg	24	$7.0 \pm 0.4^{a*}$	20	$7.4 \pm 0.2^{a,d,e*}$
No exposure + FGA-30 mg	13	$3.8 \pm 0.3^{b,d*}$	14	$5.9 \pm 0.5^{b,c,d,f\#}$
No exposure + FGA-45 mg	8	$2.8 \pm 0.3^{b,c,e*}$	6	$6.2 \pm 0.5^{e,f\#}$
Exposure				
Buck exposure (pooled)	49	$6.7 \pm 0.4^{a*}$	39	$7.3 \pm 0.3^{a\#}$
No exposure (pooled)	21	$3.3 \pm 0.3^{b*}$	20	$6.1 \pm 0.5^{b\#}$
Progestagen				
FGA-30 mg treatments (pooled)	37	$5.1 \pm 0.3^{a*}$	34	$6.5 \pm 0.4^{a\#}$
FGA-45 mg treatments (pooled)	33	$4.9 \pm 0.4^{b*}$	25	$6.8 \pm 0.4^{b\#}$
Mounts per oestrus period (pooled)	96	$5.0 \pm 0.4^{*}$	84	$6.7 \pm 0.4^{\#}$

^{a,b,c,d,e,f} Data (Mean ± SEM) in columns with different superscript letters are significantly ($P < 0.05$) different
$^{*,\#}$ Data (Mean ± SEM) in rows across seasons with different superscripts are significantly ($P<0.05$) different
FGA = Flurogestone acetate

4.16 Conception, pregnancy and kidding rates of Red Sokoto does treated with buck exposure and fluorogestone acetate in the dry and rainy season

The conception, pregnancy and kidding rates of Red Sokoto does treated with fluorogestone acetate and exposure to bucks in the dry and rainy season are shown in Table 4.16. Conception rates were similar between treatments during the dry season; although pregnancy rates were higher in the BEF3 and BEF4, compared to the F3 and F4 does. Dose of FGA did not considerably influence conception rates in the dry season. However, F4 does had a conception rate of 94 %, which was higher than 82 % obtained in the rainy season. Overall, conception rates were higher in the dry season than in the rainy season (Table 4.16). On the contrary, pregnancy rates were higher in the rainy season than in the dry season (Table 4.16).

Table 4.16: Conception, pregnancy and kidding rates of Red Sokoto does exposed to bucks and treated with polyurethane sponges impregnated with different doses of FGA in the dry and rainy seasons

Treatment groups	Dry Season					Rainy Season				
	Does treated n	Does bred n	CR n (%)	PR %	KR %	Does treated n	Does bred n	CR n (%)	PR %	KR %
Exposure and progestagens										
Buck exposure + FGA-30 mg	28	18	18 (100)	64.3	100	30	21	19 (90.5)	63.3	50.0
Buck exposure + FGA-45 mg	28	20	19 (95.0)	67.9	96.0	30	27	27 (100)	90.0	54.0
No exposure + FGA-30 mg	20	11	11 (100.0)	55.0	77.0	30	20	15 (75.0)	50.0	100
No exposure + FGA-45 mg	20	10	10 (100.0)	50.0	62.0	30	23	20 (86.9)	66.7	83.0
Exposure										
Buck exposure (pooled)	56	38	37 (97.4)	66.1	88.0	60	48	46 (95.8)	76.7	52.0
No exposure (pooled)	40	21	21 (100.0)	52.5	70.0	60	43	35 (81.4)	58.3	100
Progestagen										
FGA-30 mg treatments (pooled)	48	29	29 (100.0)	60.4	87.0	60	41	34 (82.9)	56.7	92.0
FGA-45 mg treatments (pooled)	48	30	29 (96.7)	60.4	71.0	60	50	47 (94.0)	78.3	67.0
Total (pooled)	96	59	58 (98.3)	60.4	79.0	120	91	81 (89.0)	67.5	79.0

CR = Conception rate PR = Pregnancy rate KR = Kidding rate % = Percentage n = Number
FGA = Flurogestone acetate

4.17 Oestrus response of Sahel does treated with progestagens and buck exposure in the dry and rainy seasons

The oestrus responses of SH does following different treatments in the dry and rainy seasons are shown in Table 4.17. Oestrus responses did not differ significantly between similar treatments in the dry and rainy season, except in the BEF3 does (83.3 % versus 63.3 %). Oestrus response was higher in the buck exposure (BEF3, BEF4), compared to the no-buck exposure does (F3, F4) in both the dry and rainy seasons. Furthermore, oestrus response was higher ($P < 0.05$) in the BEF4 does compared to the BEF3 does irrespective of the season (Table 4.17). Cumulative oestrus response for the BEF3 and BEF4 does was higher compared to the F3 and F4 does both the dry and rainy seasons (Figure 4.7). In this study, average oestrus occurrence was higher in the morning (08:00-10:00 h) than in the evening (16:00-18:00 h) in the dry and rainy seasons (Figure 4.7).

Table 4.17: Oestrus response of Sahel does exposed to bucks and treated with polyurethane sponges impregnated with different doses of FGA in the dry and rainy seasons

Treatment groups	Dry Season		Rainy Season	
	n	Does in oestrus (%)	n	Does in oestrus (%)
Exposure and progestagens				
I (Buck exposure + FGA-30 mg)	24	20 (83.3)	30	19 (63.3)
II (Buck exposure + FGA-45 mg)	24	17 (70.8)	30	23 (76.7)
III (No buck exposure + FGA-30 mg)	22	13 (59.1)	30	16 (53.366.7)
IV (No buck exposure + FGA-45 mg)	22	11 (50.0)	30	17 (56.7)
Exposure				
Buck exposure (pooled)	48	37 (77.1)	60	42 (70.0)
No exposure (pooled)	48	24 (50.0)	60	33 (55.0)
Progestagen				
FGA-30 mg treatments (pooled)	56	30 (53.6)	60	35 (58.3)
FGA-45 mg treatments (pooled)	40	31 (77.5)	60	40 (66.7)
Oestrus response (pooled)	92	61 (66.3)	120	75 (62.5)

n = number of does treated FGA = Fluorogestone acetate

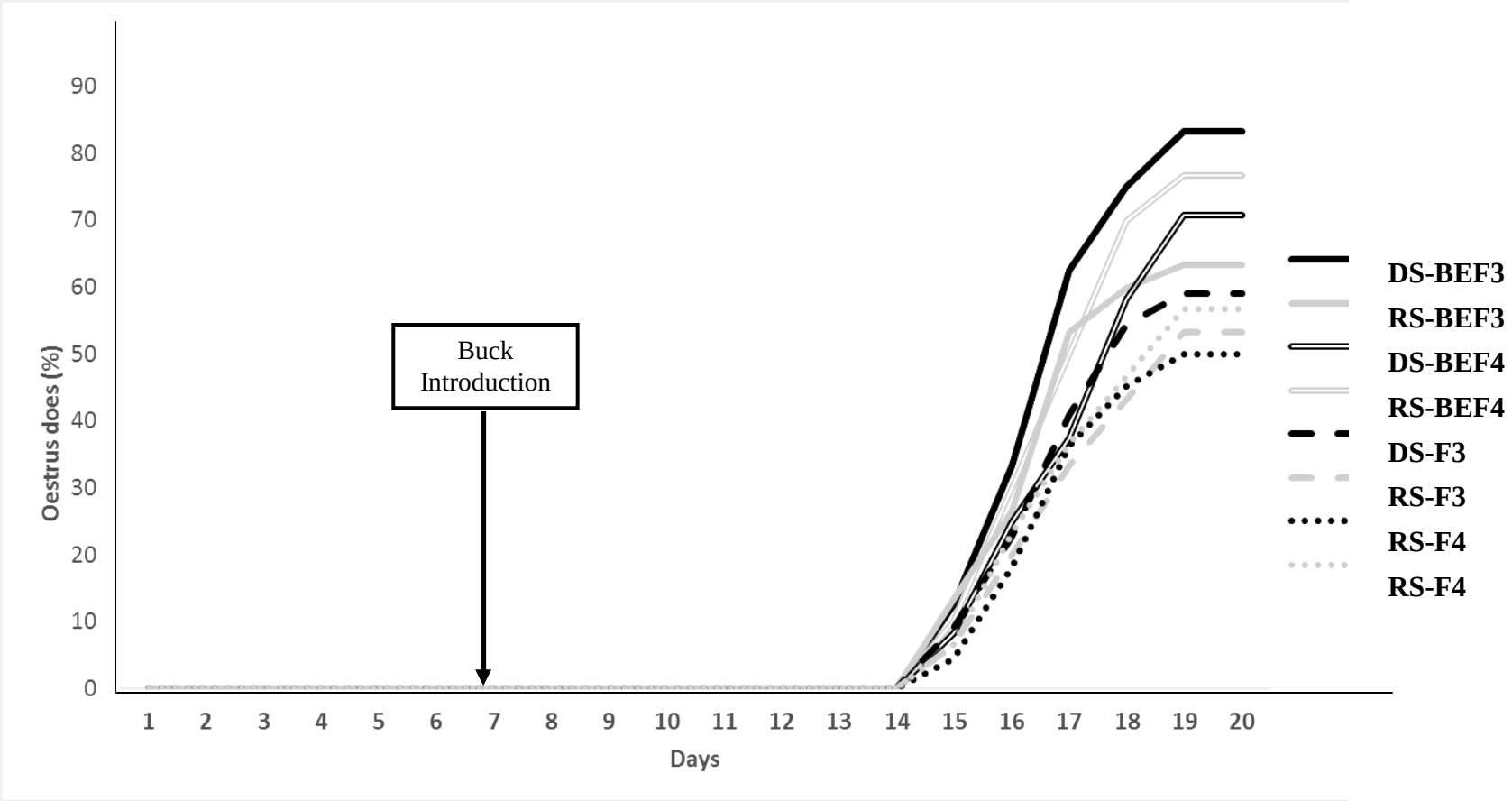


Figure 4.7: Accumulated frequency of oestrus observed over 19 days in Sahel does treated with fluorogestone acetate and buck exposure

ABEF3 = Buck exposure + FGA-30 treatment NBEF3 = No buck exposure + FGA-30 mg DS = Dry season

ABEF4 = Buck exposure + FGA-45 mg NBEF4 = No exposure + FGA-45 RS = Rainy season

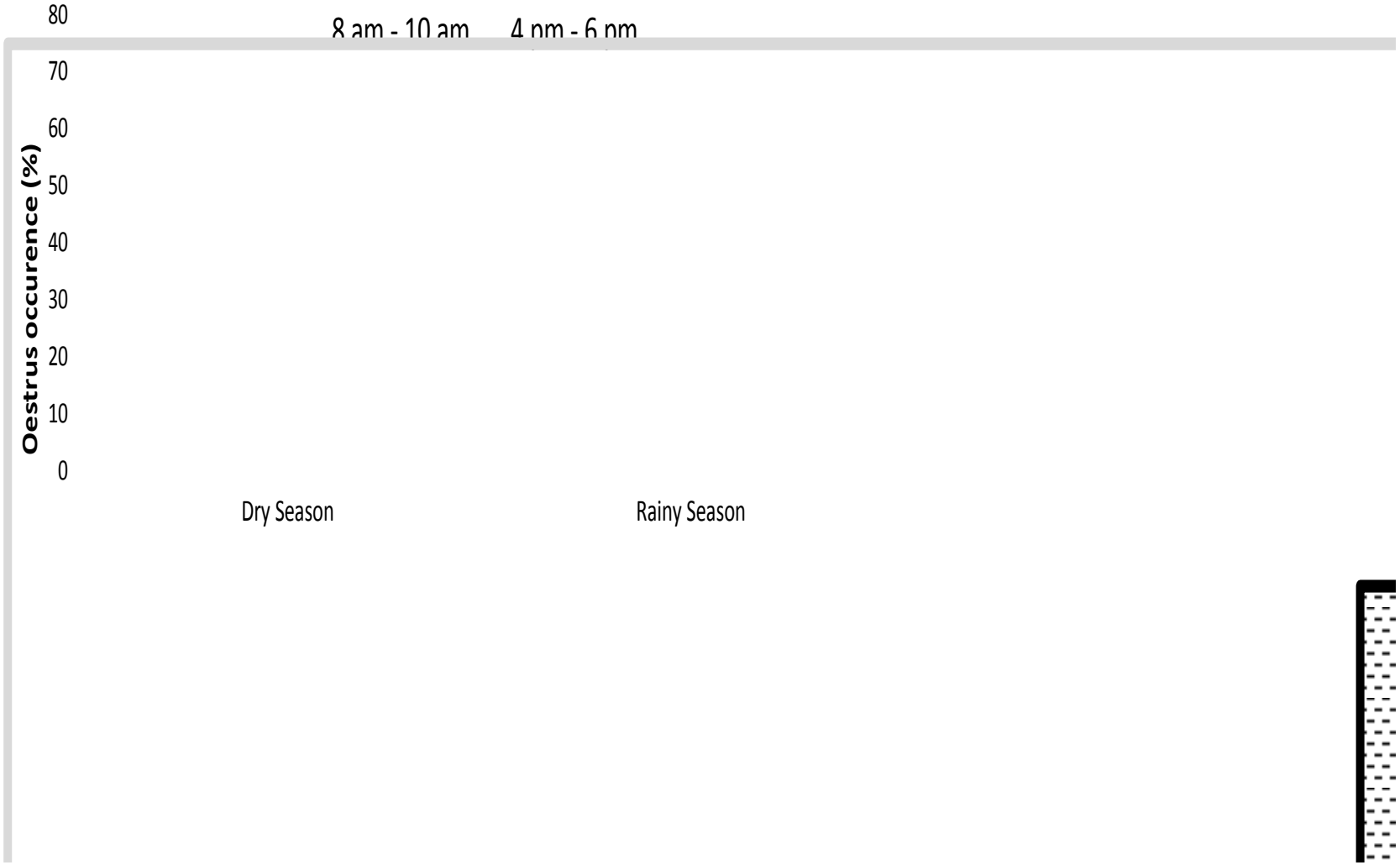


Figure 4.8: Period of oestrus occurrence observed over a 19-day period in Sahel does treated with progestagens and buck exposure in the dry and rainy season.

4.18 Interval to onset of oestrus of Sahel does treated with different doses of fluorogestone acetate and buck exposure in the dry and rainy season

The interval to onset of oestrus of Sahel does treated with FGA and exposed to buck are shown in Table 4.18. A longer ($P < 0.05$) interval to oestrus was observed in the F3 and F4 does compared to the BEF3 and BEF4 does in the dry and rainy seasons (Table 4.18). The BEF3 does were in oestrus at 36.5 h in the dry season, significantly ($P < 0.05$) shorter than the 45.8 h observed in the F3 does. Similarly, the BEF3 does were in oestrus at 31.7 h in the rainy season, significantly ($P <0.05$) shorter than the 42.2 h observed in the F3 does in the rainy season. Dose of FGA did not significantly affect time to onset of oestrus in the dry (41.2 versus 39.9 h) and rainy (36.9 versus 33.9 h) seasons, respectively. Generally, time to onset of oestrus was shorter in the rainy (35.4 h) than in the dry (40.5 h) season (Table 4.18).

Table 4.18: Interval to onset of oestrus in Sahel does exposed to bucks and treated with polyurethane sponges impregnated with different doses of FGA in the dry and rainy season

Treatment groups	Dry Season		Rainy Season	
	n	Time to onset of oestrus (h)	n	Time to onset of oestrus (h)
Exposure and progestagens				
Buck exposure + FGA-30 mg	20	36.5 ± 4.9^{a,b,c*}	19	31.7 ± 3.5^{a,b,c*}
Buck exposure + FGA- 45 mg	17	38.0 ± 3.4^{a,d,e*}	23	29.4 ± 1.7^{a,d,e*}
No exposure + FGA-30 mg	13	45.8 ± 6.2^{b,d,f*}	16	42.2 ± 2.9^{b,d,f*}
No exposure + FGA-45 mg	11	41.7 ± 5.7^{c,e,f*}	17	38.4 ± 1.9^{c,e,f*}
Exposure				
Buck exposure (pooled)	37	37.3 ± 4.2^{a*}	42	30.6 ± 2.6^{a*}
No exposure (pooled)	24	43.8 ± 5.9^{a*}	33	40.3 ± 2.4^{b*}
Progestagen				
FGA-30 mg treatments (pooled)	30	41.2 ± 5.6^{a*}	35	36.9 ± 3.2^{a*}
FGA-45 mg treatments (pooled)	31	39.9 ± 4.6^{a*}	40	33.9 ± 1.8^{a*}
Time to onset of oestrus (pooled)	61	40.5 ± 5.1*	75	35.4 ± 2.5*

^{a,b,c,d,e,f} Data (Mean ± SEM) in columns with different superscript letters are significantly ($P < 0.05$) different

$^{*,\#}$ Data (Mean ± SEM) in rows across seasons with different superscripts are significantly ($P < 0.05$) different

FGA = Fluorogestone acetate

4.19 Duration of oestrus of Sahel does treated with different doses of fluorogestone acetate and buck exposure in the dry and rainy season

The duration of oestrus of Sahel does treated with fluorgestone acetate and buck exposure in the dry and rainy season are shown in Table 4.19. No difference ($P < 0.05$) in duration of oestrus was observed in does treated with FGA with or without exposure to bucks. Duration of oestrus in the BEF3 does was 47.1 h, significantly ($P < 0.05$) longer than that of the F3 does (33.5 h) in the dry season. Longer duration of induced oestrus was also observed in the buck-exposed does (36.2 h), compared to the non-exposed does (29.5 h) in the dry season. Overall, duration of oestrus was longer ($P < 0.05$) in the rainy (37.8 h) than the dry (32.9 h) season (Table 4.19).

Table 4.19: Duration of oestrus in Sahel does exposed to bucks and treated with polyurethane sponges impregnated with different doses of FGA in the dry and rainy season

Treatment groups	Dry Season		Rainy Season	
	n	Duration of oestrus (h)	n	Duration of oestrus (h)
Exposure and progestagens				
Buck exposure + FGA-30 mg	20	$47.1 \pm 0.5^{a*}$	19	$30.2 \pm 0.6^{a\#}$
Buck exposure + FGA-45 mg	17	$25.2 \pm 1.0^{b,c*}$	23	$47.1 \pm 4.9^{b,c\#}$
No exposure + FGA-30 mg	13	$33.5 \pm 0.9^{b,c,d*}$	16	$31.1 \pm 2.4^{a,d*}$
No exposure + FGA-45 mg	11	$25.5 \pm 0.7^{b,c,e*}$	17	$42.8 \pm 5.2^{a,c,d\#}$
Exposure				
Buck exposure (pooled)	37	$36.2 \pm 0.8^{a*}$	42	$38.7 \pm 2.8^{a*}$
No exposure (pooled)	24	$29.5 \pm 0.8^{a*}$	33	$36.9 \pm 3.8^{a*}$
Progestagen				
FGA-30 mg treatments (pooled)	30	$40.3 \pm 0.7^{a*}$	35	$30.7 \pm 1.5^{a*}$
FGA-45 mg treatments (pooled)	31	$25.4 \pm 0.9^{b*}$	40	$44.9 \pm 5.1^{b\#}$
Duration of oestrus (pooled)	61	$32.9 \pm 0.8^{*}$	75	$37.8 \pm 3.3^{*}$

^{a,b,c,d} Data (Mean ± SEM) in columns with different superscript letters are significantly ($P < 0.05$) different

$^{*,\#}$ Data (Mean ± SEM) in rows across seasons with different superscripts are significantly ($P<0.05$) different

FGA = Fluorogestone acetate

4.20 Mounts per oestrus period of Sahel does treated with fluorogestone acetate and buck exposure in the dry and rainy season

The mounts per oestrus period of Sahel does treated with fluorogestone acetate and exposure to buck are shown in Table 4.20. Averagely, higher ($P < 0.05$) mounts per oestrus period was observed in buck-exposed does, compared to the non-exposed does in the dry season (Table 4.20). The BEF3 does had higher than the F3 does in the dry ($P < 0.05$) and rainy season mounts per oestrus period. Mounts per oestrus period increased with dose of fluorogestone acetate, being higher in the FGA-45 mg compared to the FGA-30 mg does. Apparently, lowest number of mounts per oestrus period was recorded in the F4 does in the dry (4.3) and rainy (5.1) seasons (Table 4.20).

Table 4.20: Mounts per oestrus period of Sahel does exposed to bucks and treated with polyurethane sponges impregnated with different doses of FGA in the dry and rainy season

Treatment groups	Dry Season		Rainy Season	
	n	Mounts per oestrus period	n	Mounts per oestrus period
Exposure and progestagens				
Buck exposure + FGA-30 mg	20	$9.1 \pm 0.5^{a*}$	19	$6.9 \pm 0.4^{a,c\#}$
Buck exposure + FGA-45 mg	17	$8.2 \pm 0.4^{a,e*}$	23	$6.5 \pm 0.4^{a,d,e*}$
No exposure + FGA-30 mg	13	$4.3 \pm 0.4^{b,d,f*}$	16	$5.1 \pm 0.3^{b,d,f*}$
No exposure + FGA-45 mg	11	$6.5 \pm 0.4^{c,e,f*}$	17	$6.3 \pm 0.2^{c,e,f*}$
Exposure				
Buck exposure (pooled)	37	$8.7 \pm 0.5^{a*}$	42	$6.7 \pm 0.4^{a\#}$
No exposure (pooled)	24	$5.4 \pm 0.4^{b*}$	33	$5.7 \pm 0.3^{b*}$
Progestagen				
FGA-30 mg treatments (pooled)	30	$6.7 \pm 0.5^{a*}$	35	$6.0 \pm 0.4^{a*}$
FGA-45 mg treatments (pooled)	31	$7.4 \pm 0.4^{a*}$	40	$6.4 \pm 0.3^{a\#}$
Mounts per oestrus period (pooled)	61	7.0 ± 1.3*	75	$6.2 \pm 0.3^{\#}$

^{a,b,c,d,e,f} Data (Mean ± SEM) in columns with different superscripts letter are significantly ($P < 0.05$) different

$^{*,\#}$ Data (Mean ± SEM) in rows across seasons with different superscripts are significantly ($P<0.05$) different

FGA = Fluorogestone acetate

4.21 Conception, pregnancy and kidding rates of Sahel does treated with fluorogestone acetate and buck exposure in the dry and rainy season

The conception, pregnancy and kidding rates of Sahel does treated with polyurethane pessaries impregnated with different doses of fluorogestone acetate and exposure to bucks in the dry and rainy seasons are shown Table 4.21. Conception rates did not differ ($P < 0.05$) between treatments during the dry season; although pregnancy rates were higher in the buck exposed does (BEF3 and BEF4), compared to the non-exposed does (F3 and F4). Dose of FGA did not significantly influence conception rates in the dry and rainy seasons. However, FGA-45 mg does had an overall conception rate of 87.9 % compared to the 72.9 %, observed in the FGA-30 mg does in the dry season. Overall, conception rate was lower ($P < 0.05$) in the dry compared to rainy season (Table 4.21). On the contrary, pregnancy rates were higher ($P < 0.05$) in the dry than rainy season (Table 4.21).

Table 4.21: Conception, pregnancy and kidding rates of Sahel does exposed to bucks and treated with polyurethane sponges impregnated with different doses of FGA in the dry and rainy season

Treatment groups	Dry Season					Rainy Season				
	Does treated	Does bred	CR n (%)	PR %	KR %	Does treated	Does bred	CR n (%)	PR %	KR %
Exposure and progestagens										
Buck exposure + FGA-30 mg	24	20	18 (90.0)	75.0	100	30	19	15 (78.9)	50.0	89.5
Buck exposure + FGA-45 mg	24	17	17 (100.0)	70.8	88.2	30	23	22 (95.7)	73.3	65.2
No exposure + FGA-30 mg	22	13	11 (84.6)	50.0	146.2	30	16	12 (75.0)	40.0	81.3
No exposure + FGA-45 mg	22	11	11 (100.0)	50.0	172.7	30	17	15 (88.2)	50.0	82.4
Exposure										
Buck exposure (pooled)	48	37	41 (83.7)	85.4	94.6	60	42	38 (97.4)	63.3	76.2
No exposure (pooled)	44	24	15 (71.4)	34.0	158.3	60	33	17 (85.0)	28.3	88.8
Progestagen										
FGA-30 mg treatments (pooled)	46	30	27 (72.9)	58.7	96.7	60	35	31 (91.2)	51.7	85.7
FGA-45 mg treatments (pooled)	46	31	29 (87.9)	63.0	109.7	60	40	24 (96.0)	40.0	72.5
Total (pooled)	92	61	56 (80.0)	60.9	126.8	120	75	55 (93.2)	45.8	79.6

CR = Conception rate PR = Pregnancy rate KR = Kidding rate % = Percentage n = Number
FGA = Fluorogestone acetate

4.22 Serum progesterone levels in Red Sokoto does treated with different progestagens with or without continuous exposure to bucks

The serum P_4 levels of exposed and non-exposed Red Sokoto does treated with different ptogestagens are shown in Figure 4.9. Mean serum progesterone levels of does treated with CIDR was greater than 3 ng/mL by day 4 with no difference between exposed and non-exposed does (4.59 ± 2.9 ng/mL vs. 3.26 0.07 ng/mL), respectively. Mean levels of serum P_4 was greater than 1.31 ng/mL on day 7 in Red Sokoto does treated with FGA-30 and exposed to buck effect. Mean progesterrone levels of 0.33 ng/mL was observed on the day of oestrus after CIDR removal (Figure 4.9).

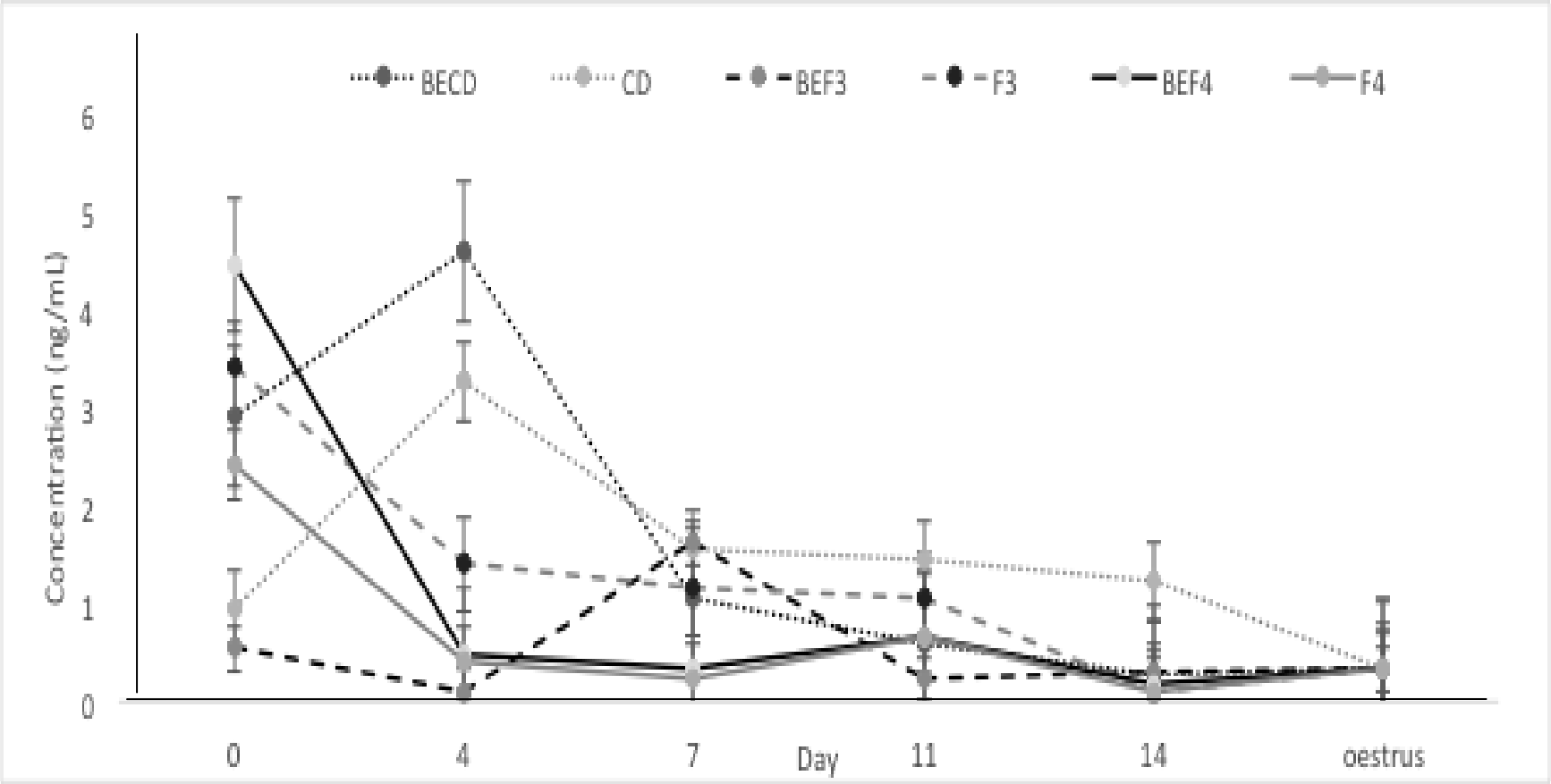


Figure 4.9: Mean progesterone concentrations of Red Sokoto does during treatment with progestagens (CIDR, FGA-30 mg and FGA-45 mg) with or without buck exposure.

BECD = Buck exposure + CIDR CD = CIDR BEF3 = Buck exposure + FGA-30

F3 = FGA-30 BEF4 = Buck exposure + FGA-45 F4 = FGA-45

4.23 Serum progesterone levels in Sahel does treated with different progestagens with or without limited exposure to bucks

The serum progesterone levels of the exposed and non-exposed Sahel does treated with different progestagens are shown in Figure 4.10. Mean serum progesterone was to 3.15 ng/ml by day 4 in does treated with CIDR without buck exposure. Mean level of serum progesterone was 4.03 ng/mL on day 11 of BECD treatment. Progesterone concentration decreased to its lowest level on day 14 (final day of treatment) with a mean level of 2.99 ng/mL (Figure 4.10).

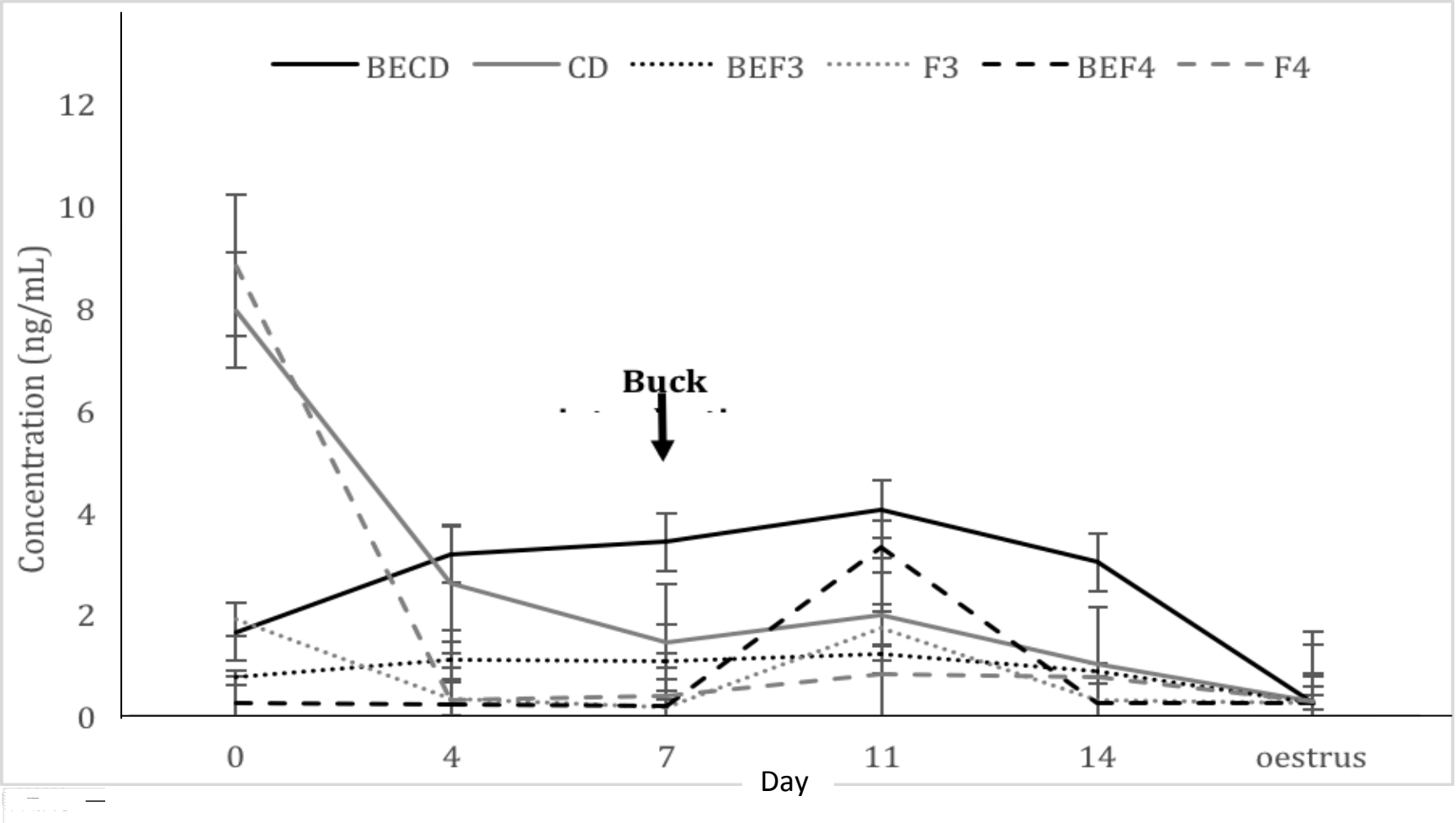


Figure 4.10: Mean progesterone concentrations of Sahel does during treatment with progestagens (CIDR, FGA-30 mg and FGA-45 mg) with or without limited buck exposure.

BECD = Buck exposure + CIDR CD = No buck exposure + CIDR BEF3 = Buck exposure + FGA-30

F3 = No buck exposure + FGA-30 BEF4 = Buck exposure + FGA-45 F4 = No exposure + FGA-45

CHAPTER FIVE

5.0 DISCUSSION

The results of the present study showed that buck effect was capable of inducing oestrus in Red Sokoto and Sahel does during the dry and rainy season; therefore, biostimulation may be exploited for increased productivity of RS and SH goats. The results of the present study indicate that continuous exposure of does to aproned bucks (biostimulation) during progesterone treatment enhanced oestrus response, increased frequency of oestrus occurrence and conception rates. This corroborates the findings of Mellado *et al*. (2000), Pellicer-Rubio *et al.* (2008) and Ungerfeld (2011), who showed that higher oestrus response and conception rates occurred when does were teased during progestagen or prostaglandin treatments. Consequently, the adoption of a proposed progestagen plus buck effect combination protocol (BuckProg Synch) for oestrus synchronisation of does is an effective alternative to the traditional progestagen plus eCG and single dose prostaglandin treatment previously reported (Kawu, 2011; Omontese *et al*., 2013a, b). The results of the present study agrees with the report of Avdi *et al*. (2004), who reported higher oestrus response in does exposed to bucks at different breeding periods of the year. Overall, the higher oestrus response observed in Sahel does in the rainy compared to the dry season breeding disagrees with the findings of Lehloenya *et al.* (2008), who reported similar oestrus response following hormonal stimulation in Boer goats during different seasons. The duration of teasing used in this study was sufficient to induce significant oestrus behaviour in Sahel does in the rainy season. This corroborates the findings of Mellado *et al*. (2000), who reported similar response in does treated with male exposure 24 and 48 hours before the end

of hormone treatments. This further suggests that duration of exposure of does to bucks during progestagen treatment does not reduce the response of does to the male effect (Veliz *et al.,* 2006, 2009).

The results of this study agree with previous reports that season, body condition and nutrition play a significant role in livestock reproduction (Rekwot *et al.,* 2000a; De Santiago-Miramontes *et al.,* 2009; Fitz-Rodríguez *et al*., 2009). The efficacy of response to the male effect is known to be influenced by variations in the quality of the stimulus provided by the male and variation in female responsiveness. The continuous or limited presence of buck during progestagen treatment allowed the aproned buck to exhibit many sexual behaviour such as vocalisation, tongue lapping, fore-leg striking and positive mount. Olfactory, visual, auditory, tactile stimuli and stage of oestrus cycle may also influence the response of the does to the male effect (Gonzalez-Bulnes *et al.,* 2006; Fitz-Rodrıguez *et al*., 2009).

The observations in this study in favour of progestagen treatment plus teasing also agree with the finding of Mellado *et al*. (2000), who reported that a greater percentage of does were in oestrus in the buck-exposed group than the non-exposed group (91.6 % and 66.6 %, respectively). It has been suggested that buck-doe interaction influences reproductive activity through olfactory cues or pheromones (Jansen van Vuuren *et al.,* 2004; Chemineau *et al.,* 2006; Delgadillo *et al.,* 2009). Teasing in the present study increased the responsiveness of does to OS through stimulation of greater LH pulse frequency, leading to a greater behavioural oestrus expression in sheep (Ungerfeld *et al.,* 2003), goats (Pellicer-

Rubio *et al.,* 2007) and cattle (Reolofs *et al.,* 2008). Dose of fluorogestone acetate influenced oestrus response in Red Sokoto does in this study. This disagrees with the findings of Simonetti *et al.* (2000) and Greyling and van der Nest (2000), who reported that dose of fluorogestone acetate did not influence oestrus response rates in Merino ewes and Boer does, respectively. The findings also disagree with the report of Omontese *et al.* (2013b) and Oyeyemi *et al*. (2012), who reported that oestrus response did not differ in Red Sokoto and West African Dwarf does treated with different intravaginal pessaries, containing different doses of exogenous hormones. Several studies have reported the influence of nutrition in reproduction (Tanaka *et al.,* 2004; Endo and Tanaka, 2015). The improved feeding during the rainy season resulted in higher body weight and body condition of does in this study.

Overall, oestrus interval after withdrawal of intravaginal progestins was shorter in the dry than the rainy season. This result supports the findings of Kawu (2011), who reported that interval to oestrus response was shorter in the dry season than in the rainy season. The present findings fell within the range reported for other breeds (Boer, Shami, Sahel) of goats (Romano, 2001; Keskin, 2003; Omontese *et al.*, 2012), but was lower than that reported for the WAD goat (Oyeyemi *et al*., 2012) and higher than that reported for Boer does (Lehloenya *et al*., 2008). Dose of FGA did not influence interval to oestrus onset in this study and comparable oestrus intervals were observed in the dry and rainy season in this study. This finding agrees with the result of Greyling and van der Nest (2000) and Simonetti *et al.* (2000), who reported that dose of FGA did not influence time to onset of oestrus.

Omontese *et al*. (2012) also reported that, different does of FGA did not affect onset of oestrus in the Sahel breed of goats.

The shorter time interval to oestrus onset observed in Red Sokoto does in the dry season after progesterone priming and teasing in this study disagrees with the findings of Ekiz *et al*. (2013) in Kivircik ewes exposed to rams during progestagen treatment. However, the results of this study corroborates the findings of Romano *et al.* (2000a) and Evans *et al*. (2004) in sheep and, Mellado *et al*. (2000) and Romano *et al.* (2001) in goats, who showed that that teasing during progestagen treatment hastened oestrus onset after pessaries withdrawal. Earlier oestrus onset observed in this study may be attributed to high oestrogen levels, produced as a result of hormonal treatment in combination with biostimulation. The average interval to onset of oestrus of does treated with progestagens with or without exposure to bucks was 29 hours and was within the range reported for other goat breeds (Mellado *et al.,* 2000; Dogan *et al.,* 2004; Romano, 2004; Omontese *et al*., 2012). The longer time interval to oestrus onset observed in Sahel does in the dry season after progesterone priming and teasing in this study agrees with the findings of Ekiz *et al*. (2013) in Kivircik ewes exposed to rams during progestagen treatment. Interval to oestrus onset after treatments ranged from 23 h to 46 h in this study. This finding was similar to the ranges reported for other breeds of goats (Greyling and van der Nest, 2000; Mellado *et al*., 2000; Abu *et al.,* 2008; Omontese *et al.,* 2010; Oyeyemi *et al.,* 2012). Buck exposure also reduced the interval to onset of oestrus in the dry season. This finding corroborates the result of Romano (2001), who reported that teasing during progestagen treatment shortened interval to oestrus occurrence. Similarly, the above findings are in agreement with the work of Keskin (2003), who reported that buck

exposure advanced expression of behavioural oestrus in Shami breed of goats following progestin treatment.

The mean oestrus duration observed in this study is similar to that reported by Omontese *et al.* (2013a, b, c, d), who obtained a range of 23 – 33 h in Red Sokoto does. The mean duration of induced oestrus period in buck-exposed does was shorter in the rainy season than dry season. This may be attributed to low oestrogen levels, resulting from low stimulation during the rainy season. In this study, teasing during progestagen treatment increased the duration of oestrus in both the rainy and dry seasons. This finding disagrees with the report of Romano and Fernandez Abella (1997), who obtained shorter oestrus duration in dairy does exposed to different mating stimuli. The duration of induced oestrus period in the buck-exposed does was longer in the rainy season than during the dry season. This might be attributed to higher oestrogen levels, resulting from increased stimulation during the rainy season. In this study, teasing during progestagen treatment did not influence the duration of oestrus in both the rainy and dry seasons. Factors that influence duration of induced oestrus after progesterone priming include teasing, type and frequency of mating stimuli (Romano, 2004).

It was observed from this study that the buck exposed does had shorter duration of oestrus, although, comparable to the non-exposed does. This result is similar to the findings of Romano (1994a), who reported shorter oestrus duration in does teased during progestagen treatment. On the other hand, oestrus duration was higher with increasing FGA dose, especially in the dry season. It appears that better nutritional status during rainy season

influenced the duration of oestrus in FGA-30 treated does. Overall, oestrus duration was longer in the rainy season compared to the dry season. The result corroborates the finding of Kawu (2011) in RS does in the same zone. Therefore, season rather than buck exposure and dose of FGA influences oestrus duration in does. The observation of the present study also agrees with the report of Romano and Fernandez Abella (1997) that stated that mating stimuli shortened oestrus duration. On the other hand, oestrus duration was higher with increased FGA dose, especially in the dry season. It appears that better nutritional status during rainy season influenced the duration of oestrus in FGA-30 treated does. Overall, oestrus duration was longer in the rainy season compared to that of the dry season. This finding corroborates the result obtained by Kawu (2011) in RS does. Therefore, season, rather than buck exposure, and dose of FGA, may influence oestrus duration in Red Sokoto and Sahel does.

The higher number of mounts per oestrus period in the does treated with CIDR and exposed to bucks compared to the non-exposed does in the dry and rainy season. This suggests that teasing influences oestrus behaviour by modifying and elevating gonadotrophin pulses, leading to stronger oestrus exhibition in does. This mechanism is hypothesized to be mediated by pheromones exerting their effects through olfactory or accessory olfactory pathways (Rekwot *et al.*, 2001; Delgadillio *et al.*, 2006, 2009). The result of the present study revealed that season influenced the number of mounts per oestrus period, as the rainy season favoured higher oestrus activity than the dry season. This may be connected with the improved nutrition, body condition and body weights observed during the rainy season breeding. The overall mounts per oestrus period reported for does in the dry season in this

study is similar to the findings of Omontese *et al.* (2013c,d) in RS goats. Importantly, teasing significantly resulted in higher oestrus response in the dry season. This suggests that exposure of does to bucks increased GnRH/LH pulses, resulting in greater follicular activity and may translate to greater overt oestrus expression in does. It is also evident from this study that dose of FGA did not influence the number of mounts per oestrus period. This study revealed that season influenced the number of mounts per oestrus period, as the rainy season favoured higher oestrus activity than the dry season. This may be connected with the improved nutrition, body condition and body weights, observed during the rainy season. The overall mounts per oestrus period reported for does in the dry season in this study is similar to the findings of Omontese *et al*. (2013c) in the same breed of goats. Importantly, teasing significantly resulted in higher oestrus response in the dry season. The result of the present study suggests that exposure of does to bucks increased GnRH/LH pulses, which results in greater follicular activity and may translate to greater overt oestrus-expression in does. It is also evident from this study that dose of FGA did not influence the number of mounts per oestrus period.

In this study, overall conception and kidding rates were higher in the rainy season than dry season, possibly due to the improved nutritional status of does, grazing improved sown pastures characteristic of the rainy season, as has been reported by several workers (De Santiago-Miramontes *et al.*, 2008, 2009; Fitz-Rodríguez *et al.*, 2009) and reduce embryonic mortality (Mani *et al*., 1992) during OS in goats. Other factors (environmental conditions, management, treatments, stress, and disease) may play a role in conception and kidding rates. Although the rainy season breeding did not significantly favour better oestrus response

in this study, conception rates were higher in the rainy than dry season. Lower conception rates were observed in does treated with intravaginal progestagen (CIDR) over those without CIDR treatment in the dry and rainy seasons. This corroborates the findings of other researchers (Agarwal and Allamaneni, 2004; Dobson *et al.*, 2012), who reported that fertility at synchronised oestrus is lower than that observed at natural oestrus. This may be attributed to the negative influence of oxidative stress and intravaginal pessaries on vaginal bacterial flora resulting in altered sperm transport in the reproductive tract and resulting fertility (Agarwal and Allamaneni, 2004; Dobson *et al.,* 2012). However, the result disagrees with the finding of Manes *et al.* (2010), who did not observe any influence of different intravaginal pessaries on subsequent fertility in ewes.

The male effect did not influence overall kidding rates and litter size irrespective of season and this corroborates the findings of Keskin (2003) in Shami goats following oestrus synchronisation with exogenous hormones and buck effect. This suggests the inability of the male stimulus to cause super-ovulatory response in the does as observed when FSH and eCG are combined with progestin treatments. Although the rainy season breeding did not significantly favour better oestrus response in this study, conception rates were higher in the rainy than in the dry season. Lower conception rates were observed in does treated with intravaginal progestagen (CIDR) over those without CIDR treatment in the dry and rainy seasons. This corroborates the findings of other researchers (Gonzalez-Bulnes *et al.,* 2005; Dobson *et al.,* 2012) who reported that fertility at synchronised oestrus is lower than that observed at natural oestrus. This may be attributed to the negative influence of oxidative stress and intravaginal pessaries on vaginal bacterial flora, resulting in altered sperm

transport in the reproductive tract and, consequently, fertility (Agarwal and Allamaneni, 2004; Dobson *et al.,* 2012). The male effect did not influence overall kidding rates and litter size, irrespective of season of breeding in this study. This corroborates the finding of Keskin (2003) in Shami goats following oestrus synchronisation with exogenous hormones and buck effect. This suggests the inability of the male stimulus to cause super-ovulatory response in the does as observed when FSH and eCG are combined with progestin treatments. Neither buck exposure nor dose of FGA influenced kidding rates of Red Sokoto does in the dry season. However, elevated conception and pregnancy rates were observed in the rainy season. This is in agreement with the finding of Taiwo *et al.* (2005) who reported that higher body condition score as observed in the rainy season, resulting in enhanced reproductive performance of Red Sokoto does. Silva *et al.* (2011) reported significantly higher pregnancy, prolificacy and twinning rates in goats with body condition of 2.7, compared to does with body condition of 2.0. This finding was attributed to the greater body reserves in does with higher body condition. However, the result disagrees with the findings of Kusina *et al*. (2000), who found no difference in the reproductive responses in Mashona goat does, maintained on pasture with low body condition. Studies have described the importance of nutritional supplementation on improved conception rates (De Santiago-Miramontes *et al.,* 2008, 2009; Fitz-Rodríguez *et al.,* 2009) and reduced embryonic mortality (Mani *et al*., 1992) after OS. Other factors including environmental conditions, management, treatments, stress, and disease may play a role in conception and kidding rates (Paulo *et al.,* 2005; Rondina and Galeati, 2010). Although the rainy season breeding favoured better oestrus response in this study, conception rates were similar in the rainy and

dry seasons. The male effect did not influence overall kidding rates irrespective of season of breeding in this study.

The result of the present study showed the elevated progesterone levels were observed from progestagen pre-insertion levels to > 3 ng/ml on day 4 of CIDR treatments. From day 4, P_4 levels declined to about 1 ng/ml. The result conformed to those of earlier findings following insertion of intravaginal progestagens in sheep and goats (Ainsworth and Downey, 1986; Ali *et al.,* 2009). Ali *et al*. (2009) reported higher mean progestagen levels of 4 ng/ml by day 6 following progestin insertion. In another study with WAD goats, the mean progesterone concentration was < 1ng/ml by day 7 of prostaglandin administration. In this study, P_4 levels did not differ significantly between the buck-exposed and non-buck exposed groups. At oestrus, mean progesterone levels declined to 0.33 ± 0.01 ng/mL, which was higher than the basal P_4 concentrations 0.1-0.2 ng/mL reported by Zarkawi (2000) and Gaafar *et al.* (2005). The mean progesterone levels observed at oestrus were similar to that reported by Ali *et al.* (2009) and Kawu *et al.* (2004) at post-partum period in the same breed of goat. The pattern of P_4 increase to maximum and then decline was similar to that reported by Hamra *et al.* (1989) who used a 9 % CIDR device and obtained a peak plasma P_4 levels of 2.2 ± 0.3 ng/ml on day four of treatment, with declining levels to 1.4 ± 0.2 ng/ml on day thirteen of treatment. Wheaton *et al*. (1993) observed almost identical results indicating that peak plasma progesterone concentrations of 2.4 ng/mL occurred on day four of treatment (Day 0 characterized by day of CIDR insertion) and declined in a gradual manner until day 13, where levels dropped to 1.5 ng/mL. This result was similar to the pattern observed in the CIDR-treated Red Sokoto does in this study.

The pattern of progesterone increase to maximum followed by a decline in this study is similar to that recorded for other goat breeds (Hamra *et al*., 1989; Wheaton *et al*., 1993; Ali *et al.,* 2009). These researchers observed plasma progesterone levels by day 4 - 6 of treatment using CIDR devices, with a decrease in P_4 levels to < 0.4 ng/mL on day 12 of treatment. Kauser *et al.* (2005) reported similar findings of peak plasma progesterone concentrations during the mid-luteal phase of the oestrus cycle in dwarf goats. Overall, serum progesterone concentration decreased from 3.54 ng/ml to 1.01 ng/mL by day 7 and remained stable till withdrawal of progestagen (day 14). Generally, in the present study, serum P_4 levels declined in all groups by day 14 of progestin insertion. Low detectable P_4 levels during oestrus may be due to the fact that ovarian follicles also produce progesterone, apart from estrogens (Singh *et al.*, 1999). The peri-ovulatory period in goats is characterized with low values of progesterone (below 1ng/mL) and the current results obtained correspond with values of other studies (Mori and Kano, 1984; Błaszczyk *et al.*, 2004). Lowest P_4 levels were observed at day of oestrus, indicating minimal luteal activity. Dose of intravaginal progestin did not influence serum progesterone profiles and concentrations. Progeserone levels were similar in the buck-exposed and non-exposed Sahel does.

CHAPTER SIX

6.0 SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1 Summary

Based on the findings of this study, the following summaries were made;

1. The continuous presence of a buck during progesterone treatment enhanced oestrus response and increased pregnancy rates in Red Sokoto does.

2. Teasing at the end of progesterone treatment enhanced oestrus response, hastened onset of oestrus and increased conception rates in SH does. The dry season favoured better kidding rates in SH does exposed to the male effect.

3. Dose of fluorgestone acetate did not influence oestrus response and overall fertility of RS does exposed to the buck effect. The rainy season breeding resulted in higher oestrus response; but with, lower conception rates.

4. The dry season breeding resulted in higher oestrus response but lower conception rates in SH does. Dose of fluorgestone acetate did not influence oestrus response and overall fertility of Sahel does exposed to the buck effect.

5. Exposure of RS and SH does to males during progestagen treatments did not significantly affect serum P_4 levels. However, Buck-exposed RS and SH does had relatively higher P_4 levels compared to the non-exposed does.

6.2 CONCLUSION

Buck exposure, progestagen treatment and season had a significant impact on oestrus behaviour and fertility of Red Sokoto and Sahel goats in the Northern Guinea Savanah zone of Nigeria.

6.3 RECOMMENDATIONS

Based on the conclusions of this study, the following recommendations were made:

1. Oestrus synchronisation programmes in RS and SH does using progestagens should be accompanied with exposure to sexually active bucks to improve oestrus response.

2. In areas with low economy and non-availability of progestagens, buck effect alone could be utilized for synchronisation of oestrus in goats.

3. Any progestagen type may be employed in oestrus synchronisation programmes, depending on availability, cost and user preference.

4. Further studies on the influence of biostimulation and season on circulating LH and FSH levels, growth of kids and onset of puberty should be carried out in RS and SH goats.

REFERENCES

Abecia, J.A., Forcada, F. and Gonzalez-Bulnes, A. (2011). Pharmaceutical control of reproduction in sheep and goats. *Veterinary Clinics, Food Animal Practice*, 27: 67–79.

Abecia, J.A., Forcada, F. and Gonzalez-Bulnes, A. (2012). Hormonal control of reproduction in small ruminants. *Animal Reproduction Science*, 130: 173-179.

Abecia, J.A., Sosa, C., Forcada, F. and Meikle, A. (2006). The effect of under-nutrition on the establishment of pregnancy in the ewe. *Reproduction Nutrition Development,* 46: 367–378.

Abu, A.H., Iheukwumere, F.C. and Onyekwere, M.U. (2008). Effect of exogenous progesterone on oestrus response of West African Dwarf (WAD) goats. *African Journal of Biotechnology*, 7 (1): 59-62.

Achiraman, S., Sankar-Ganesh, D., Kannan, S., Kamalakkannan, S., Nirmala, N. and Archunan, G. (2014). Response of male mice to odours of female mice in different stages of oestrous cycle: self-grooming behaviour and the effect of castration. *Indian Journal of Experimental Biology*, 52(1): 30-35.

Adeoye, S. A. O. (1985). Disease profiles of sheep and goats in two groups of villages in southwest Nigeria. In: Sumberg, J.E. and Cassaday, K. (eds), *Sheep and goats in humid West Africa.* Proceedings of the Workshop on Small Ruminant Production Systems in the Humid Zone of West Africa, Ibadan, Nigeria, 23–26 January 1984. ILCA, Addis Ababa, Ethiopia. pp. 13–16.

Adeyinka, I.A. and Mohammed, I.D. (2006). Accuracy of body weight prediction in Nigerian Red Sokoto Goats raised in North-eastern Nigeria using linear body measurement. *Pakistan Journal of Biological Sciences,* 9(15): 2828 – 2830.

Agarwal, A. and Allamaneni, S.S. (2004). Role of free radicals in female reproductive diseases and assisted reproduction. *Reproduction Biomedical Online*, 9: 338 - 347.

Agga, G.E., Udala, U., Regassa, F. and Wudie, A. (2011). Body measurement of three goat breeds in Ethiopia and their correlation to breed, age and testicular measurements. *Small Ruminant Research*, 95(2):133-138.

Aguirre, V., Orihuela A. and Vázquez, R. (2011). Effects of vaginal mucus from ewes in oestrus on the sexual drive and semen characteristics of hair rams (*Ovis aries*). *Journal of Veterinary Behaviour, Clinical Applications and Research*, 6(4): 239−242.

Ahmad, S., Kumar, H., Yadav, M.C., Singh, J., Singh, G. and Patra, M.K. (2010). Biostimulatory effects of bull urine on ovarian activity and reproductive performance in post-partum crossbred cows. *The Indian Journal of Animal Science*, 80(6): (Abstract).

Ainsworth, L. and Downey, B.R. (1986). A controlled internal drug release dispenser containing progesterone for control of the estrous cycle of ewes. *Theriogenology*, 26: 847–856.

Ajala, M.K. (2004). Household decision-making in the production of small ruminants in Giwa Local Government Area of Kaduna State of Nigeria. In: (Eds). *Proceedings of the 29th Annual Conference of the Nigerian Society of Animal Production. Sokoto*, Nigeria, Pp 399 – 402.

Akusu, M.O. (2003). Reproductive performance of goats for maximum animal production in Nigeria. *2002/2003 Inaugural Lecture Series, University of Ibadan*, pp 5.

Akusu, M.O., Nduka, E. and Soyebo, B.A. (1994). Peripheral plasma levels of progesterone and estradiol 17β in West African Dwarf (WAD) goats during oestrus synchronisation. *Tropical Veterinarian*, 12: 27-36.

Ali, A., Hayder, M. and Saifelnaser, E.O.H. (2009). Ultrasonic and endocrine evaluation of three regimes for oestrus and ovulation synchronisation for sheep in the sub-tropics. *Reproduction in Domestic Animals*, 44: 873-878.

Al-Katanani, Y. M., Paula-Lopes, F.F. and Hansen, P.J. (2002). Effect of season and exposure to heat stress on oocyte competence in Holstein cows. *Journal of Dairy Science*, 85: 390-396.

Almeida-Irmao, J.M., Neto, L.M.F., Moura, M.T., Neves, J.P., Lima, P.F. and Oliveira, M. A.L. (2014). Duration of the breeding season on the reproductive performance of Anglo-Nubian goats during dry and rainy periods. *Veterinary Science Development*, 4: 43 – 45.

Al-Merestani, M.R., Zarkawi, M. and Wardeh, M.F. (2003). Improving the reproductive efficiency, pregnancy diagnosis and monitoring the resumption of luteal activity in indigenous Damascus goats. *Reproduction in Domestic Animals*, 38: 36-40.

Alvarez, R.L., Martin, G.B., Galindo, F. and Zarco, L.A. (2003). Social dominance of female goats affects their response to the male effect. *Applied Animal Behavioural Science*, 84: 199-126.

Alvarez, R.L., Ramos, A.L. and Zarco, L. (2009). The ovulatory and LH responses to the male effect in dominant and subordinate goats. *Small Ruminant Research*, 83: 29-33.

Alvarez, R.L. and Zarco, Q.L. (2001). Los fenomenos de biostimulacion sexual en ovejas y cabras. *Veterinary mex*, 32: 117-129.

Alvarez, L., Zarco, L., Galindo, L., Blache, D. and Martin, G.B. (2007). Social rank and response to the male effect in the Australian Cashmere goat. *Animal Reproduction Science*, 102(3-4): 258-266.

Amer, H.A. and Hazzaa, A.M. (2009). The effect of different progesterone protocols on the reproductive efficiency of ewes during the non-breeding season. *Veterinarski Arhiv*, 79(1): 19-30.

Amer, H.A., Shawki, G. and Randa, I. (2008). Profile of steroid hormones during oestrus and early pregnancy in Arabian mares. *Slovak Veterinary Research*, 45(1): 25-32.

Amory, J.R. and Pearce, G.P. (2000). Alarm pheromones in urine modify the behaviour of weaner pigs. *Animal Welfare*, 9: 167-175.

Atti, N.F., Bocquier, F. and Khaldi, G. (2004). Performance of the fat-tailed Barbarine sheep in its native environment: Adaptive capacity to alternation of underfeeding and re-feeding periods. A review. *Animal Research*, 53: 165-176.

Avdi, M., Leboeuf, B. and Terqui, M. (2004). Advanced breeding and buck effect in Greek goats. *Livestock Production Science*, 87: 251-257.

Ayo, J.O., Oladele, S.B., Fayomi, A., Jumbo, S.D. and Hambolu, J.O. (1998). Body temperature, respiratory and heart rate in the Red Sokoto goat during the harmattan season. *Bulletin of Animal Health and Production in Africa*, 46(2): 161–166.

Baril, G., Remy, B., Beckers, J.F. and Saumande, J. (1996). Synchronisation of oestrus in goats: the relationship between eCG binding in plasma, time occurrence of oestrus and fertility following artificial insemination. *Theriogenology*, 45: 1553–1559.

Baril, G., Remy, B., Vallet, J.C. and Beckers, J.F. (1992). Effect of repeated use of progestagen-PMSG treatment for oestrus control in dairy goats out of the breeding season. *Reproduction in Domestic Animals*, 27: 161 - 168.

Baril, G., Touzé, J.L., Pignon, R. and Saumande, J. (2000). Evaluation of the efficiency of trans-rectal ultrasound to study ovarian function in goats. *Theriogenology*, 53: 379 (Abstract).

Bartlette, A., Paina, S.J., Hughes, P.E., Stott, P. and van Wettere, W.H.E.J. (2009). The effects of PG600 and boar exposure on oestrus detection and potential litter size following mating at either the induced (pubertal) or second oestrus. *Animal Reproduction Science*, 114: 219–227.

Bartlewski, P.M., Beard, A.P., Cook, S.J. and Rawlings, N.C. (2002). Ovarian activity during sexual maturation and following introduction of rams to ewe lambs. *Small Ruminant Research,* 43: 37-44.

Bassett, J.M., Bray, C.J. and Sharpe, C.E. (2001). Reproductive seasonality in domestic sows kept outdoors without boars. *Reproduction*, 121: 613−629.

Bedos, M., Flores, J.A., Fitz-Rodríguez, G., Keller, M., Malpaux, B. and Poindron, P. (2010). Four hours of daily contact with sexually active males is sufficient to induce fertile oestrus in anoestrous goats. *Hormones and Behaviour,* 58: 434–477.

Bedos, M., Velázquez, H., Fitz-Rodríguez, G., Flores, J.A., Hernández, H. and Duarte, G. (2012). Sexually active bucks are able to stimulate three successive groups of females per day with a 4-hour period contact. *Physiology and Behaviour,* 206: 259–263.

Bello, A.A. (2011). Characterisation of oestrus, endocrine events and fertility in Red Sokoto goats following comparative oestrus synchronisation with prostaglandin and progestagen. *MSc. Thesis, submitted to the School of Postgraduate Studies, Ahmadu Bello University, Zaria, Nigeria*.

Berardinelli, J.G., Joshi, P.S. and Tauck, S.A. (2005). Postpartum resumption of ovarian cycling activity in first-calf suckled beef cows exposed to familiar or unfamiliar bulls. *Animal Reproduction Science*, 90(3-4): 201-209.

Berardinelli, J., Joshi, P. and Tauck, S. (2007). Conception rates to artificial insemination in primiparous, suckled cows exposed to the bio-stimulatory effect of bulls before and during a gonadotropin-releasing hormone-based oestrus synchronisation protocol. *Journal of Animal Science,* 85(4): 848- 852.

Bertoldo, M., Grupen, C.G., Thomson, P.C., Evans, G. and Holyoake, P.K. (2009). Identification of sow-specific risk factors for late pregnancy loss during the seasonal infertility period in pigs. *Theriogenology*, 72: 393−400.

Bezerra, F.Q.G., Aguiar-Filho, C.R., Frietas-Nato L.M., Sanos-Junior, L.R, Chaves, R.M. and Azevado, E.M.P. (2009). Body weight, scrotal circumference and testosterone concentration in young Boer goat males born during the dry and rainy seasons. *South African Journal of Animal Science*, 39(4): 301-306.

Billings, H.J. and Katz, L.S. (1997). Progesterone facilitation and inhibition of estradiol-induced sexual behaviour in the female goat. *Hormonal Behaviour,* 31: 47–53.

Bindari, Y.R., Shrestha, S., Shrestha, N. and Gaire, T.N. (2013). Effects of nutrition on reproduction- A review. *Advances in Applied Science Research*, 4(1): 421-429.

Blaszczyk, B., Stankiewicz, T. and Udala, J. (2013). The intravaginal and electrical impedance measurements in monitoring the oestrous cyclicity, the length of the breeding season and ovarian cysts in goats. *Small Ruminant Research*, 113: 109-114.

Blaszczyk, B., Udala, J. and Gaczarzewicz, D. (2004). Changes in oestradiol, progesterone, melatonin, prolactin and thyroine concentrations in blood plasma of goats following induced oestrus in and outside the natural breeding season. *Small Ruminant Research*, 51: 209-219.

Blench, R.M. (1999). Traditional livestock breeds: Geographical distribution and dynamics in relation to the ecology of West Africa. Overseas Development Institute, Portland House Stag Place, London, SW1E 5DP. Pp 37-39.

Borisenkov, M.F., Kalinin, A.I. and Vakhnina, N.A. (2004). Seasonal dynamics of cattle reproduction in the North. *Russian Journal of Ecology*, 35: 205−208.

Boyazoglu, J., Hatziminaoglou, I. and Morand-Fehr, P. (2005). The role of the goat in society: Past, present and perspectives for the future. *Small Ruminant Research*, 60: 13-23.

Boyazoglu, J. and Morand-Fehr, P. (2001). Mediterranean diary sheep and goat products and their quality. *Small Ruminant Research*, 40: 1-11.

Bretzlaff, K.N. and Romano, J.E. (2001). Advanced reproductive techniques in goats. *Veterinary Clinics North America Food Animal Practice*, 17: 421–434.

Burguete, I., Quiles, A., Ramirez, A., Hevia, M.L. and Vallejo, M. (1998). Effect of buck, year and season of insemination on prolificacy of Murciano–Granadina goats. *Small Ruminant Research*, 29: 121–123.

Carrillo, E., Tejada, I.M., Mezza-Herrera, C.A., Arrelano-Rodriguez, G., Garcia, J.E., De Santiago-Miramontes, M.A., Mellado, M. and Veliz, F.G. (2011). Response of sexually inactive French Alpine bucks to the stimulus of goats in oestrus. *Livestock Science*, 141: 202-206.

Castro, T, Rubianes, E., Menchaca, A. and Rivero, A. (1999). Ovarian dynamics, serum estradiol and progesterone concentrations during the inter-ovulatory interval in goats. *Theriogenology*, 52: 399–411.

Celi, I., Gatica, M.C., Guzman, J.I., Gallego-Calvo, L. and Zarazaga, L.A. (2013). Influence of the male effect on the reproductive performance of female Payoya goats implanted with melatonin at the winter solstice. *Animal Reproduction Science*, 137:183-188.

Chang, T.K. and Landauer, W. (1950). Observation on the skeleton of African Dwarf goats. *Journal of Morphology*, 86: 367-80.

Chanvallon, A., Blache, D., Chadwick, A., Esmaili, T., Hawken, P.A.R., Martin, G.B., Vinoles, C. and Fabre-nys, C. (2010). Sexual experience and temperament affect the response of Merino ewes to the ram effect during the anoestrous season. *Animal Reproduction Science*, 119: 205-211.

Chemineau, P. (2012). A foresight reflection on sustainable methods for controlling mammalian farm animal reproduction. *Tropical and Subtropical Agroecosystems*, 15(1): 1-14.

Chemineau, P., Daveau, A., Cognie, Y., Aumont, G. and Chesneau, D. (2004). Seasonal ovulatory activity exists in tropical Creole female goats and Black Belly ewes subjected to a temperate photoperiod. *BMC Physiology*, 4: 12.

Chemineau, P., Guillaume, D., Migaud, M., Thiéry, J.C., Pellicer-Rubio, M.T. and Malpaux, B. (2008). Seasonality of reproduction in mammals: Intimate regulatory mechanisms and practical implications. *Reproduction in Domestic Animals*, 43: 40-47.

Chemineau, P., Pellicer-Rubio, M., Lassoued, N., Khaldi, G. and Monniaux, D. (2006). Male-induced short oestrous and ovarian cycles in sheep and goats: a working hypothesis. *Reproduction, Nutrition and Development*, 46: 417-429.

Chentouf, M., Bister, J.L. and Boulanouar, B. (2011). Reproduction characteristics of North Morrocan indigenous goats. *Small Ruminant Research*, 98: 115 – 188.

Christensen, A.C.M., Haresign, W. and Khalid, M. (2014). Progesterone exposure of seasonally anoestrous ewes alters the expression of angiogenic growth factors of pre-ovulatory follicles. *Theriogenology*, 81: 358-367.

Concannon, P.W. (2011). Reproductive cycles of the domestic bitch. *Animal Reproduction Science*, 124: 200 – 210.

Cote, D.S. and Festa-Bianet, M. (2001). Reproductive success in female mountain goats: the influence of age and social rank. *Animal Behaviour*, 62: 173-181.

Cushwa, W.T., Bradford, G.E., Stabenfeldt, G.H., Berger, Y.M. and Dally, M.R. (1992). Ram influence on ovarian and sexual activity in anestrous ewes: effects of isolation of ewes from rams before joining and date of ram introduction. *Journal of Animal Science*, 70: 1195–1200.

Dare, A.T., Rekwot, P.I., Aliu, Y.O., Mamman, M., Obidi, J.A., Omontese, B.O., Chiezey, N.P. and Rwuaan, J.S. (2010). Effect of season and progesterone-releasing

intravaginal device alone or with pregnant mare serum gonadotropin on fertility rates of Bunaji cows. *Research Journal of Dairy Sciences*, 4(1): 1-5.

Daudu, C. (1984). Spermatozoa output, testicular sperm reserve and epididymal storage capacity of the Red Sokoto goats indigenous to Northern Nigeria. *Theriogenology*, 21: 317–324.

De Bond, J.A.P., Li, Q., Millar, R.P., Clarke, I.J. and Smith, J.T. (2013). Kisspeptin Signaling is required for the luteinizing hormone response in anoestrous ewes following the introduction of males. *PLoS ONE*, 8(2): 57972-57972.

De Gier J., Kooistra, H.S., Djajadiningrat-Laanen, S.C., Dieleman, S.J. and Okkens, A.C. (2006). Temporal relations between plasma concentrations of luteinizing hormone, follicle-stimulating hormone, estradiol-17β, progesterone, prolactin, and α-melanocyte-stimulating hormone during the follicular, ovulatory, and early luteal phase in the bitch. *Theriogenology*, 65: 1346–1359.

De Santiago-Miramontes, M.A., Malpaux, B. and Delgadillo, J.A. (2009). Body condition is associated with a shorter breeding season and reduced ovulation rate in subtropical goats. *Animal Reproduction Science*, 114: 175–182.

De Santiago-Miramontes, M.A., Rivas-Munoz, R., Munoz-Gutierrez, M., Malpaux, B., Scaramuzzi, R.J. and Delgadillo, J.A. (2008). The ovulation rate in anoestrous female goats managed under grazing conditions and exposed to the male effect is increased by nutritional supplementation. *Animal Reproduction Science*, 105: 409–416.

Delgadillo, J.A. (2011). Environmental and social cues can be used in combination to develop sustainable breeding techniques for goat reproduction in the subtropics. *Animal*, 5: 74–81.

Delgadillo, J.A., De La Torre-Villegas, S., Arellano-Solis, V., Duarte, G. and Malpaux, B. (2011a). Refractoriness to short and long days determines the end and onset of the breeding season in subtropical goats. *Theriogenology*, 76: 1146–1151.

Delgadillo, J.A., Fitz-Rodriguez, G., Duarte, G., Veliz, F.G., Carrillo, E., Flores, J.A., Vielma, J., Hernandez, H. and Malpaux, B. (2004). Management of photoperiods in control of caprine reproduction in the subtropics. *Reproduction, Fertility and Development*, 16:471-478.

Delgadillo, J.A., Flores, J.A., Duarte, G., Vielma, J., Hernanadez, H., Bedos, M., Fitz-Rodriguez, G., Fernandez, I.G., Lopez-Sebastian, A., Gomez-Brunet, A., Santiago-Moreno, J., Zarazaga, L.A., Keller, M. and Chemineau, P. (2014). Out-

of-season control of reproduction in subtropical goats without exogenous hormonal treatments. *Small Ruminant Research*, 121(1): 7-11.

Delgadillo, J.A., Flores, J.A., Hernández, H., Poindron, P., Keller, M. and Fitz-Rodríguez, G. (2015). Sexually active males prevent the display of seasonal anoestrus in female goats. *Hormonal Behaviour*, 69: 8-15.

Delgadillo, J.A., Flores, J.A., Veliz, F.G., Duarte, G. and Hernandez, H. (2006). Importance of the signals provided by the buck for the success of the male effect in goats. *Reproduction, Nutrition and Development*, 46:391-400.

Delgadillo, J.A., Flores, J.A., Veliz, F.G., Hernandez, H.F., Duarte, G., Vielma, J., Poindron, P., Chemineau, P. and Malpaux, B. (2002). Induction of sexual activity in lactating anovulatory female goats using male goats treated only with artificially long days. *Journal of Animal Science*, 80: 2780–2786.

Delgadillo, J.A., Gelez, H., Ungerfeld, R., Hawken, P.A.R. and Martin, G.B. (2009). The "male effect" in sheep and goats: revisiting the dogmas. *Behavioral Brain Research*, 200: 304–314.

Delgadillo, J.A., Ungerfeld, R., Flores, J.A., Hernanadez, H. and Fitz-Rodriguez, G. (2011b). The ovulatory response of anestrous goats exposed to the male effect in the subtropics is unrelated to their follicular diameter at male exposure. *Reproduction in Domestic Animals*, 46: 687-691.

Devendra, C. (2001). Small ruminants: Imperatives for productivity enhancement improved livelihoods and rural growth. A review. *Asian-Australian Journal of Animal Science*, 10: 1483-1496.

Dhanda, J.S. (2001). Evaluation of crossbred goat genotypes for growth, carcass and meat quality characteristics. Ph.D. Thesis, University of Queensland, Australia.

Dhanda, J.S., Taylor, D.G., Murray, P.J., Pegg, R.B. and Shand, P.J. (2003). Goat Meat Production: Present Status and Future Possibilities. *Asian-Australian Journal of Animal Science*, 16(12): 1842-1852.

Diskin, M.G., Austin, E.J. and Roche, J.F. (2002). Exogenous hormonal manipulation of ovarian activity in cattle. *Domestic Animal Endocrinology*, 23: 211–228.

Dobson, H., Fergani, C., Routly, J.E. and Smith, R.F. (2012). Effect of stress on reproduction in ewes. *Animal Reproduction Science*, 130: 135-140.

Dogan, I., Nur, Z., Gunay, U., Soylu, M.K. and Sonmez, C. (2004). Comparison of fluorogestone aand medroxyprogesterone intravaginal sponges in oestrus

synchronisation in Saanen does during the transition period. *South African Journal of Animal Science,* 34: 1 – 8.

Drion, P.V., Furtoss, V., Baril, G., Manfredi, E., Bouvier, F., Pougnard, J.L., Bernelas, D., Caugnon, P., McNamara, E.M., Remy, B., Sulon, J., Beckers, J.F., Bodin, L. and Lebuf, B. (2001). Four years of induction/synchronisation of oestrus in dairy goats: Effect on the evolution of eCG binding rate in relation with the parameters of reproduction. *Reproduction Nutrition Development*, 41: 401-412.

Dubeuf, J.P., Morand-Fehr, P. and Rubino, R. (2004). Situation, changes and future of goat industry around the world. *Small Ruminant Research*, 51: 165-173.

East, N.E. and Rowe, J.D. (1989). Subcutaneous progestin implants versus intravaginal sponges for dairy goat oestrus synchronisation during the transitional period. *Theriogenology, 32*: 921-927.

Ebozoje, M.O. and Ikeobi, C.O.N. (1998). Colour variation and reproduction in the West African Dwarf (WAD) goats. *Small Ruminant Research*, 27(2): 125-130.

Eduvie, L.O. (1985). Factors affecting postpartum ovarian activity and uterine involution in Zebu cattle indigenous to Nigeria. *Animal Reproduction Science*, 8: 123-128.

Egerszegi, I., Sarlos, P., Ratky, J., Solti, L., Faigl, V. Kulcsar, M. and Cseh, S. (2014). Effect of melatonin treatment on semen parameters and endocrine function in black Racka rams out of the breeding season. *Small Ruminant Research*, 116: 192-198.

Ekiz, E.E., Ekiz, B. and Kocak, O. (2013). Effects of ram presence during synchronisation period and previous experience on certain oestrus parameters and sexual behaviours in Kıvırcık ewes. *Turkish Journal of Veterinary and Animal Sciences*, 37: 189-193.

Ekiz, E., Matur, E., Arslan, E., Akyazi, M., Ozcan, I. (2009). Influence of ram presence (permanent vs. intermittent) on oestrus parameters and behaviours in Kivircik ewes. *Dtsch Tierarztl Wochenschr*, 116: 260–265.

Endo, N. and Tanaka, T. (2015). Effect of intermittent administration of neurokin 3 receptor agonist on luteinizing hormone secretion, oestrus, and ovulation in feed-restricted goats. *Small Ruminant Research*, 127: DOI: 10.1016/j.smallrumres.2015.04.011

Epstein, H. and Mason, I.I. (1971). The Savannah goats of Africa. In: *The Origin of the Domestic Animals of Africa, R*evised edition. Africana Publishing Corporation. New York London, Munich, pp. 236 – 293.

Evans, A.C., Flynn, J.D., Quinn, K.M., Daffy, P., Quinn, P., Madgwick, S., Crosby, T.F., Boland, M.P. and Beard, A.P. (2001). Ovulation of aged follicles does not affect embryo quality or fertility after a 14-day progestagen oestrus synchronisation protocol in ewes. *Theriogenology,* 15: 923–936.

Evans, A.C.O., Duffy, P., Crosby, T.F., Hawken, P.A.R., Boland, M.P. and Beard, A.P. (2004). Effect of ram exposure at the end of progestagen treatment on oestrus synchronisation and fertility during the breeding season in ewes. *Animal Reproduction Science,* 84: 349-358.

Food and Agricultural Organization (2003): Cattle and small ruminant production systems in sub-saharan Africa: a systematic review. Food and Agricultural Organization, Rome.

Food and Agricultural Organization (2013): Optimizing feed use efficiency in ruminant animal production systems. Retrieved January 18, 2013, from http:/www.fao.org/ag/againfo/home/en/news.

FAOSTAT (2009). Food and Agricultural Organization Statistical Databases.

Fasanya, O.O.A., Molokwu, E.C.I., Eduvie, L.O. and Dim, N.I. (1992a). Dietary supplementation in the Savanna Brown goat. I: Effect on attainment of puberty in the doe. *Animal Reproduction Science,* 29: 157-166.

Fasanya, O.O.A., Molokwu, E.C.I., Eduvie, L.O. and Dim, N.I. (1992b): Dietary supplementation in the Savanna Brown goat. I: Gestation and postpartum ovarian activity in primiparous does. *Animal Reproduction Science,* 29: 167-174.

Fatet, A., Pellicer-Rubio, M.T. and Leboeuf, B. (2011). Reproductive cycle of goats. *Animal Reproduction Science*, 124: 211–219.

Faye, D., Sulon, J., Kane, Y., Beckers, J.F., Leak, S., Kaboret, Y., de Sousa, N.M., Losson, B. and Geerts, S. (2004). Effects of an experimental *Trypanosoma congolense* infection on the reproductive performance of West African Dwarf goats. *Theriogenology*, 62(8): 1438-451.

Fierro, S., Gil, J., Vinoles, C. and Olivera-Muzante, J. (2013). The use of prostaglandins in controlling oestrous cycle in the ewe: A review. *Theriogenology,* 79: 399-408.

Fiol, C., Quintans, G. and Ungerfeld, R. (2010). Response to biostimulation in peri-puberal beef heifers: influence of male-female proximity and heifer's initial body weight. *Theriogenology*, 74:569-575.

Fitz-Rodríguez, G., De Santiago-Miramontes, M.A., Scaramuzzi, R.J., Malpaux, B., and Delgadillo, J.A. (2009). Nutritional supplementation improves ovulation and

pregnancy rates in female goats managed under natural grazing conditions and exposed to the male effect. *Animal Reproduction Science,* 116: 85–94.

Fletcher, C.M., Jackson, D.J. and Whitley, N.C. (2002). Use of 48-hour kid removal to decrease the post-partum rebreeding interval in meat does. *Journal of Animal Science*, 80(1): 290-295.

Flores, J.A., Véliz, F.G., Pérez-Villanueva, J.A., Martínez de la Escalera, G., Chemineau, P., Poindron, P., Malpaux, B. and Delgadillo, J.A. (2000). Male reproductive condition is the limiting factor of efficiency in the male effect during seasonal anoestrous in female goats. *Biology of Reproduction*, 62: 1409–1414.

Fonseca, J.F. and Torres, C.A. (2005). Administration of hCG 5 days after breeding and reproductive performance in nulliparous dairy goats. *Reproduction in Domestic Animals*, 40:495-499.

Fonseca, J.F., Torres, C.A.A., Costa, E.P., Maffili, V.V., Carvalho, G.R., Alves, N.G. and Rubert, M.A. (2005). Progesterone profile and reproductive performance of oestrous-induced Alpine goats given hCG five days after breeding. *Animal Reproduction*, 2(1): 54-59.

Forcada, F. and Abecia, J.A. (2006). The effect of nutrition on the seasonality of reproduction in ewes. *Reproduction Nutrition Development*, 46: 355−365.

Freitas, V. J., Baril, G. and Saumande, J. (1996). Induction and synchronisation of oestrus in goats: the relative efficiency of one versus two fluorogestone acetate-impregnated vaginal sponges. *Theriogenology*, 46: 1251–1256.

Freitas, V.J.F., Baril, G. and Saumande, J. (1997). Oestrus synchronisation in dairy goats: use of fluorogestone acetate vaginal sponges or norgestomet ear implants. *Animal Reproduction Science,* 46: 237-244.

Fukui, Y., Ishikawa, D., Ishida, N., Okada, M., Itagaki, R. and Ogiso, T. (1999). Comparison of fertility of estrous synchronised ewes with four different intravaginal devices during the breeding season. *Journal of Reproduction and Development,* 45: 337-343.

Gaafar, K.M., Gabr, M.K. and Teleb, D.F. (2005). The hormonal profile during the oestrus cycle and gestation in Damascus goats. *Small Ruminant Research*, 57: 85-93.

Galal, S. (2005). Biodiversity in goats. *Small Ruminant Research,* 60: 75 – 81.

Galindo, F. and Broom, D.M. (2000). The relationships between social behaviour of dairy cows and the occurrence of lameness in three herds. *Research in Veterinary Science,* 69: 75-79.

Gallego-Calvo, L., Gatica, M.C., Celi, I., Guzmán, J.L., Delgadillo, J.A. and Zarazaga, L.A. (2014). No previous isolation of female goats is required for novel males to induce a male effect, especially if direct physical contact is established. *Theriogenology*, 82 (9): 1310–1315.

Gallego-Calvo, L., Gatica, M.C., Guzmán, J.L. and Zarazaga, L.A. (2015). Reproductive performance response to the male effect in goats is improved when doe live weight/body condition score is increasing. *Animal Reproduction Science,* doi:10.1016/j.anireprosci.2015.03.001.

Gatti, M. and Ungerfeld, R. (2012). Intravaginal sponges to synchronise oestrus decrease sexual attractiveness in ewes. *Theriogenology*, 78(8): 1796-1799.

Gelez, H., Lindsay, D.R., Blache, D., Martin, G.B. and Fabre-Nys, C. (2003). Temperament and sexual experience affect female sexual behaviour in sheep. *Applied Animal Behavioural Science*, 84: 81-87.

Gelez, H., Archer, E., Chesneau, D., Magallon, T. and Fabre-Nys, C. (2004). Importance of learning in the response of ewes to the male odor. *Chemical Senses*, 29: 555-563.

Gelez, H. and Fabre-Nys, C. (2004). The "male effect" in sheep and goats: a review of the respective roles of the two olfactory systems. *Hormonal Behaviour*, 46:, 257–271.

Gelez, H. and Fabre-Nys, C. (2006). Role of the olfactory systems and importance of learning in the ewes' response to rams or their odors. *Reproduction, Nutrition, Development*, 46: 401–415.

Ginther, O.J. and Kot, K. (1994). Follicular dynamics during the ovulatory season in goats. *Theriogenology*, 42: 987–1001.

Godfrey, R.W., Collins, J.R. and Hensley, E.L. (2001). Behavioural and endocrine responses of hair sheep ewes exposed to different mating stimuli around oestrus. *Theriogenology*, 55:877-884.

Gokuldas, P.P., Yadav, M.C., Kumar, H., Singh, G., Mahmood, S. and Tomar, A.K.S. (2010). Resumption of ovarian cyclicity and fertility response in bull-exposed postpartum buffaloes. *Animal Reproduction Science*, 121(3): 236-241.

Gómez-Brunet, A., Santiago-Moreno, J., del Campo, A., Malpaux, B., Chemineau, P., Tortonese, D.J., Gonzalez-Bulnes, A. and López-Sebastián, A. (2008). Endogenous circannual cycles of ovarian activity and changes in prolactin and melatonin secretion in wild and domestic female sheep maintained under a long day photoperiod. *Biology of Reproduction*, 78: 552−562.

Gondogan, M., Baki, D. and Yeni, D. (2003). Reproductive seasonality in sheep. *Acta Agriculturae Scandinavia Sect A Scie,* 53: 175-179.

Gonzalez-Bulnes, A., Carrizosa, J.A., Urrutia, B. and Lopez-Sebastian, A. (2006). Development of preovulatory follicles in goats induced to ovulate using the male effect with or wthout progesterone priming. *Reproduction, Fertility and Develepment*, 18(7): 745 – 750.

Gonzalez-Bulnes, A., Diaz-Delfa, C., Garcia-Garcia, R.M., Urrutia, B., Carrizosa, J.A. and Lopez-Sebastian, A. (2005). Origin and fate of preovulatory follicles after induced luteolysis at different stages of the luteal phase of the oestrous cycle in goats. *Animal Reproduction Science*, 86: 237–245.

Goodman, B.L., Thiery, J.C., Delaleu, B. and Malpaux, B. (2000). Oestradiol increases multiunit electrical activity in the A15 area of ewes exposed to inhibitory photoperiods. *Biology of Reproduction*, 63: 1352-1957.

Grammer, K., Fink, B. and Neave, N. (2005). Human pheromones and sexual attraction. *European Journal of Obstetrics, Gynecology and Reproductive Biology*, 118(2): 135-142.

GraphPad Prism Version 5.0 (2009). GraphPad Software, San Diego, California, USA (www.graphpad.com).

Greyling, J.P.C. (2000). Reproductive attributes of the Boer goat doe. *Small Ruminant Research*, 36: 171-177.

Greyling, J.P.C., Mmbengwa, V.M., Schwalbach, L.M.J. and Muller, T. (2004). Comparative milk production potential of Indigenous and Boer goats under two feeding management systems in South Africa. *Small Ruminant Research*, 55(1): 97-105.

Greyling, J.P.C. and van der Nest, M. (2000). Synchronisation of oestrus in goats: dose effect of progestagen. *Small Ruminant Research,* 36: 201-207.

Guiseppe, P. and Giovanni, C. (2002). Biological rhythm in livestock. *Journal of Veterinary Science*, 3: 145-157.

Hamra, A.H., McNally, J.W., Maracek, J.M., Carlson, K.M. and Wheaton, J.E. (1989) Comparison Of progesterone sponges, cronolone sponges and controlled internal-drug release dispensers on fertility in anoestrous ewes. *Animal Reproduction Science,* 18: 219-226.

Hashemi, M., Safdarian, M. and Kafi, M. (2006). Oestrous response to synchronisation of oestrus using different progesterone treatments outside the natural breeding season in ewes. *Small Ruminant Research*, 65: 279-283**.**

Hawken, P.A.R. and Beard, A.P. (2009). Ram novelty and the duration of ram exposure affects the distribution of mating in ewes exposed to rams during the transition into the breeding season. *Animal Reproduction Science*, 111: 249-260.

Hawken, P.A.R., Beard, A.P., Esmaili, T., Kadakowa, H., Evans, A.C.O., Blanche, D. and Martin, G.B. (2007). The introduction of rams induces pulsatile LH secretion in cyclic ewes during the breeding season. *Theriogenology*, 68: 56-66.

Hawken, P.A.R., Beard, A.P., O'Meara, C.M., Duffy, P., Quinn, K.M., Crosby, T.F., Boland, M.P. and Evans, A.C.O. (2005). The effects of ram exposure during progestagen oestrus synchronisation and time of ram introduction post progestagen withdrawal on fertility in ewes. *Theriogenology*, 63: 860-871.

Hawken, P.A.R., Esmaili, T., Jorre de St Jorre, T. and Martin, G.B. (2009). Do cyclic female goats respond to males with an increase in LH secretion during the breeding season? *Animal Reproduction Science*, 112(3-4): 384–389.

Hawken, P.A.R., Evans, A.C.O. and Beard, A.P. (2008). Short-term, repeated exposure to rams during the transition into the breeding season improves the synchrony of mating in the breeding season. *Animal Reproduction Science*, 108: 13-21.

Hawken, P.A.R. and Martin, G.B. (2012). Sociosexual stimuli and gonadotropin-releasing hormone/luteinizing hormone secretion in sheep and goats. *Domestic Animal Endocrinology*, 43(2): 85-94.

Hemsworth, P.H. and Tilbrook, .A.J. (2007). Sexual behaviour of male pigs. *Hormones and Behaviour*, 52(1): 39-44.

Hervé, V., Roy, F., Bertin, J., Guillou, F. and Maurel, M. (2004). Antiequine chorionic gonadotropin (eCG) antibodies generated in goats treated with eCG for the induction of ovulation modulate the luteinizing hormone and follicle-stimulating hormone bioactivities of eCG differently. *Endocrinology*, 145(1): 294-303.

Hoffman, L.C., Sheridan, R. and Ferreria, A.V. (2002). The carcass proximate and fatty acid composition of Boer goats and South African Mutton Merinos raised under intensive feedlot conditions. *In: Proceedings of the 48th International Congress of Meat Science and Technology, August 1-6, Rome, Italy. pp. 676-677.*

Hogan, N., Waas, J.R. and Verkerk, G.A. (2004). Can female–female stimulation of breeding condition occur in dairy goats? *Small Ruminant Research*, 55: 21–27.

Holtz, W. (2005). Recent developments in assisted reproduction in goats. *Small Ruminant Research*, 60: 95-110.

Holtz, W., Sohnrey, B., Gerland, M. and Driancourt, M.A. (2008). Ovsynch synchronisation and fixed-time insemination in goats. *Theriogenology*, 69: 785-792.

Hughes, P.E. and Thorogood, K.L. (1999). A note on the effects of contact frequency and time of day of boar exposure on the efficacy of the boar effect. *Animal Reproduction Science,* 57: 121-124.

Husein M.Q., Ababneh M.M. and Haddad S.G. (2005). The effects of progesterone priming on reproductive performance of GnRH–$PGF_{2\alpha}$-treated anestrous goats. *Reproduction Nutrition Development,* 45: 689 - 698.

Ichimaru, T., Mogi, K., Ohkura, S., Mori, Y. and Okamura, H. (2008). Exposure to ram wool stimulates gonadotropin-releasing hormone pulse generator activity in the female goat. *Animal Reproduction Science,* 106: 361-368.

Igbokwe, I.O., Grema, H.A., Ikpo, A.E., Mshelbwala, F.M. and Igbokwe, N.A. (2009). Unilateral cryptorchidism in Nigerian Sahel bucks. *International Journal of Morpholo*gy, 27(3): 805-810.

Igono, M.O., Molokwu, E.C.I. and Aliyu, Y.O. (1982a). Effect of season on the oestrous cycle of Yankasa sheep. *Theriogenology,* 18: 261-266.

Igono, M.O., Molokwu, E.C.I. and Aliu, Y.O. (1982b). Body temperature responses in savannah brown goats to the harmattan and hot-dry seasons. *International Journal of Biometeorology*, 2(1): 225–230.

Iwata, E., Kikusui, T., Takeuchi, Y. and Mori, Y. (2003). Substances derived from 4-ethyl octanoic acid account for primer pheromone activity for the male effect in goats. *Journal of Veterinary Medical Science,* 65: 1019-1021.

Iwata, E., Wakabayashi, Y., Kakuma, Y., Kikusui, T., Takeuchi, Y. and Mori, Y. (2000). Testosterone-dependent primer pheromone production in the sebaceous gland of male goat. *Biology of Reproduction,* 62: 806–810.

Iwata, E., Wakabayashi, Y., Matsuse S., Kikusui, T., Takeuchi, Y. and Mori, Y. (2001) Induction of primer pheromone production by dihydro-testosterone in the male goat. *Journal of Veterinary Medical Science*, 63: 347–348.

James, I.J., Osinowo, O. A. and Ajegbile, L.T. (2005). Factors affecting milk yield in West African Dwarf goats. *Proceedings of the 30th Annual Conference of the Nigerian Society for Animal Production*, volume 30, Pp. 19-21.

Jansen van Vuuren, H.J., Booth, K.K. and Webb, E.C. (2004). Preliminary results on the role of the vomeronasal organ in modulating the response to the buck effect in does. *South African Journal of Animal Science*, 34: 95-97.

Jarosz, S.D., Deans, R.J. and Dukelow, W.R. (1971). The reproductive cycle of the African Pygmy and Toggenburg goat. *Journal of Reproduction and Fertility*, 24: 119-123.

Johnson, L.A., Weitze, K.F., Fiser, P. and Maxwel, W.M.C. (2000) Storage of boar semen. *Animal Reproduction Science*, 62: 143–172.

Jorre De St Jorre, T., Hawken, P., Esmaili, T., Machado, T., Scanlan, V. and Martin, G. (2008). Neuroendocrine pathways in the 'female effect' in sheep. *Reproduction in Domestic Animals*, 43(3): 143-144.

Kanuya, N.L., Kessy, B.M., Nkya, R. and Mujuni, P.F. (2000). Plasma progesterone concentrations and fertility of indigenous small East African goats bred after treatment with cloprostenol. *Small Ruminant Research*, 35: 157–161.

Karaca, F., Ataman, M.B. and Coyan, K. (2009). Synchronisation of oestrus with short- and long-term progestagen treatments and the use of GnRH prior to short-term progestagen treatment in ewes. *Small Ruminant Research*, 81: 185–188.

Karakus, K., Eyduran, E., Aygun, T. and Javed, K. (2010). Appropriate growth model describing some testicular characteristics in Norduz male lambs. *Journal of Animal and Plant Sciences*, 20(1): 1-4.

Karsch, F.J. (1984). *The Hormonal Control of Reproduction*. Cambridge: Cambridge University Press. Pp. 10-19.

Kauser, R., Khanum, S.A. and Hussain, M. (2005). Characterization of endocrine events at oestrus in dwarf goats (Capra Hircus). *Pakistan Veterinary Journal*, 25(3): 143-145.

Kawu, M.U. (2000). Post-partum uterine and ovarian changes and the effect of oestrus synchronisation on rebreeding in the Savannah Brown goat. *MSc. Thesis, Faculty of Veterinary Medicine, Ahmadu Bello University, Zaria, Nigeria.*

Kawu, M.U. (2011). Influence of season on prostaglandin $F_{2\alpha}$ induced oestrus synchronisation, profiles of endocrine and serum metabolites during the oestrous cycle in Savannah Brown goats. *PhD Dissertation submitted to the Post Graduate School, Ahmadu Bello University, Zaria, Nigeria.*

Kawu, M.U., Eduvie, L.O., Lakpini, C.A.M., Ayo, J.O. and Molokwu, E.C.I. (2003). Preliminary observations on oestrus synchronisation and early rebreeding using Synchromate-B in Red Sokoto (Maradi) goat. In: *Proceedings of the 28th Annual Conference of the Nigerian Society for Animal Production, Ibadan*, Pp. 30-33.

Kawu, M.U., Eduvie, L.O., Lakpini, C.A.M. and Ayo, J.O. (2004). Peripheral serum progesterone profile in multiparous Red Sokoto goats between days 1 and 30 postpartum. In: *Proceedings of the 29th Annual Conference of the Nigerian Society for Animal Production, Ife, 29*: Pp. 100-104.

Kawu, M.U., Eduvie, L.O., Lakpini, C.A.M. and Ayo, J.O. (2007). Peripheral serum progesterone profile in multiparous Nigerian Red Sokoto goats between day one and 30 postpartum. *Veterinarski Arhiv*, 77: 543-550.

Kaya, S., Kacer, C., Kaya, D. and Aslan, S. (2013). The effectiveness of supplemental administration of progesterone with GnRH, hCG and $PGF_{2\alpha}$ on the fertility of Tuj sheep during the non-breeding season. *Small Ruminant Research*, 113: 365-370.

Kemp, B., Soede, N.M. and Langendijk, P. (2005). Effects of boar contact and housing conditions on oestrus expression in sows. *Theriogenology*, 63: 643–656.

Kendrick, K.M. (2014). Pheromones: the scent of a male. *Current Biology*, 24(6): 228-230.

Kendrick, K.M., De Costa, A.P., Leigh, A.E., Hinton, M.R. and Peirce, J.W. (2001). Sheep don't forget a face. *Nature*, 414: 165-166.

Keskin, M. (2003). Influence of the buck effect and exogenous hormone treatments on oestrus synchronisation and litter size in Sharmi (Damascus) goats. *Turkish Journal of Veterinary and Animal Science*, 27: 453-457.

Keverne, E.B. (2002). Mammalian pheromones: from genes to behaviour. *Current Biology*, 12: 807−809.

Khanh, N.P., Rosnina, Y., Omar, M.A., Dhaliwal, G.K., Wahid, H., Khumran, A.M., Yap, K.C., Fahmi, M. and Azmil, A. (2012). Effects of biostimulation on oestrus behaviour, ovulation time and conception rate in primiparous and multiparous beef cows. *Journal of Animal and Veterinary Advances*, 11: 404-411.

Khanum, S.A., Hussain, M. and Kausar, R. (2006). Manipulation of estrous cycle in Dwarf goat *(Capra hircus)* using estrumate under different management conditions. *Animal Reproduction Science*, 92: 97–106.

Kirkwood, R.N., Aherne, F.X., Monaghan, P.G. and Misutka, S.C. (2000). Breeding gilts at natural or a hormone-induced oestrus: effects on performance over four parities. *Swine Health and Production*, 8: 177–179.

Knights, M., Baptiste, Q.S., Dixon, A.B., Pate, J.L., Marsh, D.J., Inskeep, E.K. and Lewis, P.E. (2003). Effects of dosage of FSH, vehicle and time of treatment on ovulation

rate and prolificacy in ewes during the anoestrous season**.** *Small Ruminant Research*, 50: 1–9.

Knox, R.V., Miller, G.M., Willenburg, K.L. and Rodriquez-Zas, S.L. (2002). Effect of frequency of boar exposure and adjusted mating times on measure of reproductive performance in weaned sows. *Journal of Animal Science*, 80: 892–899.

Kojima, F. N., Salfen, B.E., Bader, J.F., Ricke, W.A., Lucy, M.C., Smith, M.F. and Patterson, D.J. (2000). Development of an estrus synchronisation protocol for beef cattle with short-term feeding of melengestrol acetate: 7-11 Synch. *Journal of Animal Science*, 78: 2186–2191.

Krzymowski, T., Grzegorzewski, W., Stefańczyk-Krzymowska, S., and Skipor, J. (1999). Humoral pathway for transfer of the boar pheromone, androstenol, from the nasal mucosa to the brain and hypophysis of gilts. *Theriogenology*, 52(7): 1225-1240.

Kusina, N.T., Chinuwo, T., Hamudikuwanda, H., Ndlovu, L.R. and Muzanenhamo, S. (2001). Effect of dietary energy level intakes on efficiency of oestrus synchronisation fertility in Mashona goat does. *Small Ruminant Research*, 39: 283-288.

Kusina, N.T., Tarwirei, F., Hamudikuwanda, H., Agumba, G. and Mukwena, J. (2000). A comparison of the effects of progesterone sponges and ear implants, PGF_{2alpha}, and their combination on efficacy of oestrus synchronisation and fertility of Mashona goat does. *Theriogenology*, 53: 1567–1580.

Kwari, H.D., Sivachelvan, M.N. and Chibuzo, G.A. (2004). Characterisation of Sahel goats in Borno State, Nigeria for certain qualitative traits. *Nigerian Journal of Experimental and Applied Biology*, 5: 151-154.

Landeata-Hernandez, A.J., Melandez, P., Bartolomew, J., Rae, D.O. and Archbald, L.F. (2006). Effect of biostimulation on the expression of oestrus in postpartum Angus cows. *Theriogenology*, 66(4): 710-716.

Langendijk, P., Soede, N.M., Bouwman, E.G. and Kemp, B. (2000). Responsiveness to boar stimuli and change in vulvar reddening in relation to ovulation in weaned sows. *Journal of Animal Science*, 78(12): 3019-3026.

Lassoued, N., Rekik, M. and Salem, B.H. (2009). Influence of supplementary feeding and the ram effect on conception rate of Barbarine ewes during spring mating. *Options Mediterranennes*, 85: 405-409.

Lebbie, S.H.B. (2004). Goats under household conditions. *Small Ruminant Research*, 51: 131–136.

Le Danvic, C., Gérard, O., Sellem, E., Ponsart, C., Chemineau, P., Humblot, P. and Nagnan-Le Meillour, P. (2015). Enhancing bull sexual behavior using oestrus-specific molecules identified in cow urine. *Theriogenology*, 83: 1381–1388.

Lehloenya, K.C., Greyling, J.P.C. and Grobler, S. (2008). Effect of season on the super-ovulatory response in Boer goat does. *Small Ruminant Research*, 78: 74-79.

Leigh, O.O. and Ajibade, Z.O. (2010). Conception following trans-cervical insemination with predetermined ejaculate concentration in synchronised West African Dwarf does. *Global Veterinaria*, 5(4): 239-42.

Levy, F., Keller, M. and Poindron, P. (2004). Olfactory regulation of maternal behavior in mammals. *Hormonal Behaviour*, 46: 284–302.

Llewelyn, C.A., Perrie, J., Luckins, A.G. and Munro, C.D. (1993). Oestrus in the British White Goat: Timing of plasma luteinizing hormone (LH) surge and changes in behavioural and vaginal traits in relationship to onset of oestrus. *British Veterinary Journal*, 149(2): 171-181.

Lopes (Jr), E.S., Rondina, D., Simplicio, A.A. and Frietas, V.J.F. (2001). Oestrus behavior and performance *in vivo* of Saanen goats raised in Northeast of Brazil. *Livestock Research for Rural Development*, 13: Article 136, retrieved on the 12th of November, 2013 from http://cipav.org.co/lrrd/lrrd13/6/lopes136.htm.

Lopez-Sebastian, A., Gonzalez-Bulnes, A., Carrizosa, J., Urrutia, B., Diaz-Delfa, C., Santiago-Moreno, J. and Gomez-Brunet, A. (2007). New oestrus synchronisation and artificial insemination protocol for goats based on male exposure, progesterone and cloprostenol during the non-breeding season. *Theriogenology*, 68(8): 1081-1087.

Loya-Carrera, J., Bedos, M., Ponce-Covarrubias, J.L., Hernández, H., Chemineau, P., Keller, M. and Delgadillo, J.A. (2014). Switching photo-stimulated males between groups of goats does not improve the reproductive response during the male effect. *Animal Reproduction Science*, 146(1): 21-26.

Luna-Orozco, J.R., Fernandez, I.G., Gelez, H. and Delgadillo, J.A. (2008). Parity of female goats does not influence their oestrous and ovulatory responses to the male effect. *Animal Reproduction Science*, 106: 352–360.

Luna-Orozco, J.R., Guillen-Muñoz, J.M., De Santiago-Miramontes, M.A., García, J.E., Rodríguez-Martínez, R., Meza-Herrera, C.A., Mellado, M. and Véliz, F.G. (2012). Influence of sexually-inactive bucks subjected to long photoperiod or testosterone on the induction of oestrus in anovulatory goats. *Tropical Animal Health and Production*, 44: 71–75.

Macchi, E., Cucuzza, A.S., Badino, P., Odore, R., Re, F., Bevilacqua, L. and Malfatti, A. (2010). Seasonality of reproduction in wild boar (*Sus scrofa*) assessed by fecal and plasmatic steroids. *Theriogenology*, 73: 1230−1237.

Madej, A., Lang, A., Brandt, Y., Kindahl, H., Madsen, M.T. and Einarsson, S. (2005). Factors regulating ovarian function in pigs. *Domestic Animal Endocrinology*, 29(2): 347-361.

Madsen, M.T., Larsen, M., Mathiasen, J., Kindahl, H., Einarsson, S. and Madej, A. (2002). Plasma levels of oxytocin and PGF2α metabolite during AI and mating in multiparous sows. *Reproduction in Domestic Animals*, 37: 242-242.

Maina, V.A., Chaudhari, S.U.R. and Mshelia, G.D. (2006). Spermiogram of white ecotype Sahel bucks in Maiduguri Metropolis. *Pakistan Journal of Biological Sciences*, 9 (2): 307-309.

Manes, J., Fiorentino, M.A., Kaiser, G., Hozbor, F., Alberio, R., Sanchez, E. and Paolicchi, F. (2010). Changes in the aerobic vaginal flora after treatment with different intravaginal devices in ewes. *Small Ruminant Research*, 94: 201-204.

Mani, A.U., McKelvey, W.A.C. and Watson, E.D. (1992). The effects of low level of feeding on response to synchronisation to oestrus, ovulation rate and embryo loss in goats. *Theriogenology*, 38: 1013–1022.

Marai, I.F.M., El-Darawani, A.A., Fidiel, A. and Abdel-Hafez, M.A.M. (2007). Physiological traits as affected by heat stress sheep-a review. *Small Ruminant Research*, 71: 1-12.

Margiasso, M.E., Longpre, K.M. and Katz, L.S. (2010). Partner preference: assessing the role of the female goat. *Physiology of Behaviour*, 99: 587–591.

Martin, G.B. and Kadokawa, H. (2006). "Clean, green, and ethical" animal production. Case study: reproductive efficiency in small ruminants. *Journal of Reproduction and Development*, 52: 145-152.

Martin, G.B., Milton, J.T., Davidson, R.H., Banchero-Hunzicker, G.E., Lindsay, D.R. and Blanche, D. (2004a). Natural methods for increasing reproductive efficiency in small ruminants. *Animal Reproduction Science*, 82: 231-245.

Martin, G.B., Rodger, J. and Blanche, D. (2004b). Nutritional and environmental effects on reproduction in small ruminants. *Reproduction, Fertility and Development*, 16: 491-501.

Maurel, M.C., Roy, F., Hervé, V., Bertin, J., Vaiman, D., Cribiu, E., Manfredi, E., Bouvier, F., Lantier, I., Boue, P. and Guillou, F. (2003). Immune response to equine

chorionic gonadotropin used for the induction of ovulation in goats and ewes. *Gynaecology, Obstetrics and Fertility*, 31(9): 766-769.

McCosh, R.B., Berry, E.M., Wehrman, M.E., Redden, R.R., Hallford, D.M. and Berardinelli, J.G. (2015). Temporal concentrations of cortisol and LH in virgin ewes acutely exposed to rams during the transition into the breeding season. *Animal Reproduction Science,* 154: 25-28.

Medan, M.S., Sasaki, K., Groome, N.P, Sharawy, S. and Kazuyoshi, T. (2005). Follicular and hormonal dynamics during the oestrous cycle in goats. *Journal of Reproduction and Development,* 51: 455-463.

Medan, M. S., Watanabe, G., Sasaki, K., Nagura, Y., Sakaime, H., Fujita, M., Sharawy, S. and Taya, K. (2003a). Ovarian and hormonal response of female goats to active immunization against inhibin. *Journal of Endocrinology*, 177: 287-294.

Medan, M.S., Watanabe, G., Sasaki, K., Sharawy, S., Groome, N.P. and Taya, K. (2003b). Ovarian dynamics and their associations with peripheral concentrations of gonadotropins, ovarian steroids, and inhibin during the oestrous cycle in goats. *Biology of Reproduction*, 69: 57-63.

Mellado, M. and Hernandez, J.R. (1996). Ability of androgenized goat wethers and does to induce oestrus in goats under extensive conditions during anoestrous and breeding seasons. *Small ruminant Research*, 23:37-42.

Mellado, M. and Heza-Herrera, C.A. (2002). Influence of season and environment in fertility of goats in a hot-arid environment. *The Journal of Agricultural Science (Cambridge),* 138: 97-102.

Mellado, M, Olivas, R. and Ruiz, F. (2000). Effect of buck stimulus on mature and pre-pubertal norgestomet treated goats. *Small Ruminant Research,* 36: 269-274.

Mellado, M., Rodriguez, A., Olvera, A., Villarreal, J.A. and Lopez, R. (2004). Age, body condition and diets of grazing goats. *Journal of Rangeland Ecology and Management*, 57(5): 517-523.

Menchaca, A. and Rubianes, E. (2001). Effect of high progesterone levels during the early luteal phase on the length of the ovulatory cycle of the goat. *Animal Reproduction Science*, 68: 69–76.

Menchaca, A. and Rubianes, E. (2002). Relation between progesterone concentrations during the early luteal phase and follicular dynamics in goats. *Theriogenology*, 57: 1411–1419.

Menchaca, A. and Rubianes, E. (2007). Pregnancy rate obtained with short-term protocol for timed artificial insemination in goats. *Reproduction in Domestic Animals*, 42: 590-593.

Metodiev, N., Raicheva, E. and Ralchev, I. (2010). Influence of the salt-free-salt diet and the ram effect on main reproductive traits of ewes from synthetic population Bulgarian milk. *Bulgarian Journal of Agricultural Science*, 16(6): 788-793.

Meza-Harrera, C.A., Reyes-Avila, J.M., Tena-Sempere, M., Veliz-Deras, F.G., Macias-Cruz, U., Rodriguez-Martinez, R. and Arellano-Rodriguez, G. (2014). Long-term beta-carotene supplementation positively affects serum triiodothyronine concentrations around onset of puberty in female goats. *Small Ruminant Research*, 116: 176-182.

Midau A., Kibon, A., Moruppa, S.M. and Augustine C. (2010). Influence of season on milk yield and milk composition of Red Sokoto goats in Mubi area of Adamawa State, Nigeria. *International Journal of Dairy Science*, 5: 135-141.

Mocklin, C.M., Paccamonti, D.L., Eilts, B.E., Lyle, S.K., Wouters, E.G.H., Gentry, L.R. and Godke, R.A. (2006). Effects of post-ovulatory $PGF_{2\alpha}$ or cloprostenol on plasma progesterone concentration in mares. *Animal Reproduction Science*, 94: 220-224.

Moeini, M.M., Moghaddam, A.A., Bahirale, A. and Hajarian, H. (2007). Effects of breed and progestin source on oestrus synchronisation and rates of fertility and fecundity in Iranian Sanjabi and Lori ewes. *Pavlov Journal of Biological Science*, 10(21): 3801-3807.

Molokwu, E.C.I. and Ummuna, N.N. (1980). Reproductive performance of Yankasa sheep in Nigeria. *Theriogenology*, 14: 239-248.

Moore, N.W. and Hall, D.R.H. (1992). Articial insemination using the buck effect to partially synchronised Cashmere goats. *New Zealand Journal of Animal Production*, 51: 143-146.

Morales-Terán, G., Herrera-Corredor, C.A., Pérez- Hernández, P., Salazar-Ortiz, J, and Sánchez, J.G. (2011). Influence of controlled suckling and the male effect on the resumption of postpartum ovarian activity in Pelibuey sheep. *Tropical and Subtropical Agroecosystems*, 13: 493-500.

Morand-Fehr, P., Boutonnet, J., Devendra, C., Dubeuf, J.P., Haenlein, G., Holst, P., Mowlem, I. and Capote, J. (2004). Strategy for goat farming in the 21st century. *Small Ruminant Research*, 51(2): 175-183.

Mori, Y. and Kano, Y. (1984). Changes in plasma concentrations of LH, progesterone and oestradiol in relation to the occurrence of luteolysis, oestrus and time of ovulation in the Shiba goat (*Capra hircus*). *Journal of Reproduction and Fertility*, 72: 223 – 230.

Mostafa, T., Khouly, G.E. and Hassan, A. (2012). Pheromones in sex and reproduction: Do they have a role in humans? *Journal of Advanced Research*, 3: 1-9.

Munoz-Gutierrez, M., Blache, D., Martin, G.B. and Scaramuzzi, R.J. (2002). Folliculogenesis and ovarian expression of RNA encoding aromatase in anoestrous sheep after 5 days of glucose or glucosamine infusion or supplementary lupin feeding. *Reproduction*, 124: 721-731.

Murata, K., Tamogami, S., Itou, M., Ohkubo, Y., Wakabayashi, Y., Watanabe, H., Okamura, H., Takeuchi, Y. and Mori, Y. (2014). Identification of an olfactory signal molecule that activates the central regulator of reproduction in goats. *Current Biology*, 24(6): 681-686.

Nakao, N., Ono, H. and Yoshimura, T. (2008). Thyroid hormone action on intermediary metabolism. *Journal of Molecular Medicine*, 62: 946-2716.

Ndamukong, K.J.N., Sewell, M.M.H. and Asanji, M.F. (1989). Management and productivity of small ruminants in the North-west province of Cameroon. *Tropical Animal Health and Production*, 21: 109-119.

Nielson, B.L., Jerome, N., Saint-Albin, A., Rampin, O and Maurin, Y. (2013). Behavioural response of sexually naïve and experienced male rats to the smell of 6-methyl-5-heptene-2-one and female rat faeces. *Physiology and Behaviour*, 120: 150-155.

Nikolakopoulos, E., Kindahl, H., Gilbert, C.L., Goode, J. and Watson, E.D. (2000). Release of oxytocin and prostaglandin F-2 alpha around teasing, natural service and associated events in the mare. *Animal Reproduction Science*, 63(1-2): 89-99.

Nishimura, K., Utsumi, K., Yuhara, M., Fujitani, Y. and Iritani, A. (2005). Identification of puberty-accelerating pheromones in male mouse urine. *Journal of Experimental Zoology*, 251: 300-305.

Ngere, L.O., Adu, I. F. and Okubanjo, I. O. (1984). The indigenous goats of Nigeria. *Animal Genetic Resources Information*, 3: 1–9.

Norrby, M., Madsen, M.T., Borg, A.C., Kindahl, H. and Madej, A. (2007). Plasma concentrations of cortisol and PGF2α metabolite in Danish sows during mating, and intrauterine and conventional insemination. *Acta Veterinaria Scandinavia*, 49(36): 1-7.

Norrby, M., Madsen, M.T., Borg, A.C. and Madej, A. (2008). Changes in oxytocin secretion during intrauterine insemination and mating in sows. *Reproduction in Domestic Animals*, 43: 121-121.

Nuti, L.C., Bretzlaff, K.N., Elmore, R.G., Meyers, S.A., Rugila, J.N., Brinsko, S.P., Blanchard, T.L. and Weston, P.G. (1992). Synchronisation of oestrus in dairy goats treated with prostaglandin F_{2a} at various stages of the estrous cycle. *American Journal of Veterinary Research*, 53: 935-937.

Nwoko, N. and Ibe, S.N. (2005). Effect of breed and season on semen quality and fertility of bucks in a humid tropical environment. *Nigerian Journal of Animal Production*, 32: 327-334.

Odeyinka, S.M. and Okunade, G.K. (2005). Goat production in Oyo state: A case study of Ogbomoso town. *Nigerian Journal of Animal Production*, 32(1): 108-115.

Odo, B.I. (2003). Technical note: Comparative study of some prevalent diseases of ecotype goats reared in south-eastern Nigeria. *Small Ruminant Research*, 50: 203–207.

Ogede, P.O., Ogunmodede, B.K. and Dowell, L.R. (1996). Behavioural and physiological responses of Nigerian dwarf goats to seasonal changes in the humid tropics. *Small Ruminant Research*, 22: 213-217.

Ohkura, S., Ichimaru, T., Itoh, F., Matsuyama, S. and Okamura, H. (2004). Further evidence for the role of glucose as a metabolic regulator of hypothalamic gonadotropin-releasing hormone pulse generator activity in goats. *Endocrinology*, 145: 3239–3246.

Okamura, H. and Mori, Y. (2005). Characterisation of the primer pheromone molecules responsible for the male effect in ruminant species. *Chemical Senses*, 30: 1140-1141.

Okonkwo, J.C., Okonkwo I.F. and Ebuh, G.U. (2011). Effect of breed, sex and source within breed on the haematological parameters of the Nigerian goats. *Online Journal of Animal and Feed Resources*, 1(1): 8–13.

Oladimeji, B.S., Osinowo, O.A., Alawa, J.P. and Hambolu, J.O. (2001). Seasonal effects on oestrus patterns and progesterone profiles of Yankasa ewes of different age-groups in the sub-humid tropics. *Nigerian Journal of Animal Production*, 28(2): 211-216.

Oliveira, M.A.L., Guido, S.I. and Lima, P.F. (2001). Comparison of different protocols used to induced and synchronise oestrus cycle of Saanen goats. *Small Ruminant Research*, 40(2): 149 – 153.

Olivier, J.J., Cloete, S.W.P., Schoeman, S.J. and Muller, C.J.C. (2005). Performance testing and recording in meat and dairy goats. *Small Ruminant Research*, 60: 83-93.

Omontese, B.O. (2009). Synchronisation of oestrus using EAZI-BREED™CIDR® and FGA-30® vaginal sponges in prepartum Red Sokoto does and Yankasa ewes. *DVM Project, Faculty of Veterinary Medicine, Ahmadu Bello University, Zaria*.

Omontese, B.O. (2012). Oestrus synchronisation in Red Sokoto and Sahel does using progestagens and gonadotrophin. *MSc. Thesis, Faculty of Veterinary Medicine, Ahmadu Bello University, Zaria.*

Omontese, B.O., Rekwot, P.I., Makun, H.J., Ate, I.U. and Rwuaan, J.S. (2012). Induction of oestrus in Sahel goats using Fluorogestone acetate (FGA) sponges and equine chorionic gonadotrophin (eCG). *Sokoto Journal of Veterinary Science,* 10(2): 21-25.

Omontese, B.O., Rekwot, P.I., Makun, H.J., Obidi, J.A., Rwuaan, J.S. and Chiezey, N.P. (2010). Evaluation of EAZI-BREED™ CIDR® and FGA-30® intravaginal sponges as synchronising agents in prepartum Red Sokoto does. *Journal of Veterinary Research*, 3(3): 64-69.

Omontese, B.O., Rekwot, P.I., Rwuaan, J.S., Ate, I.U. and Makun, H.J. (2013a). Effect of prostaglandin and equine chorionic gonadotrophin on oestrus behaviour of Sahel goats during the harmattan season. *Livestock Research for Rural Development*, 25 (2): Article #031. Retrieved from http://www.lrrd.org/lrrd25/2/omon25031.htm.

Omontese, B.O., Rekwot, P.I., Rwuaan, J.S., Ate, I.U. and Makun, H.J. (2013b). Comparative oestrus induction in indigenous Sahel goats using two progestagens (CIDR and FGA) and eCG. *Livestock Research for Rural Development*, 25 (04): Article #066. Retrieved from http://www.lrrd.org/lrrd25/4/omon25066.htm

Omontese, B.O., Rekwot, P.I., Ate, I.U., Rwuaan, J.S. and Makun, H.J. (2013c). Oestrus synchronisation using two intravaginal progestagens (FGA and CIDR) for eCG-estrus induction in indigenous Red Sokoto goats during the cold dry season. *Albanian Journal of Agricultural Science,* 12(2): 209-213.

Omontese, B.O., Rekwot, P.I., Makun, H.J., Ate, I.U., Rwuaan, J.S. and Kawu, M.U. (2013d). Oestrus induction using fluorogestone acetate sponges and equine chorionic gonadotrophin in Red Sokoto goats. *South African Journal of Animal Science*, 43(1): 68-73.

Osinowo O.A. (1990). Breed selection, reproduction and breed management in the local small ruminant breeds. In: *The Nigeria sheep and goat production Manual. Osinowo, O.A. and Abatan, A.A. (Eds.) NAPRI, ABU, Zaria*, pp. 7 – 18.

Otaru, S.M., Adamu, A.M., Ehoche, O.W. and Makun, H.J. (2011). Effects of varying levels of palm oil on feed intake, milk yield and composition and postpartum weight changes in of Red Sokoto goats. *Small Ruminant Research,* 96: 25-35.

Otuma, M.O. (2006). Evaluation of different crossbreeding programmers, season and sex on body weight and linear traits of Nigeria goats. *Journal of Agriculture Food Environment Extension*, 2(4): 34-37.

Otuma, O.M. and Osakwe, I.I. (2008). Estimation of genetic parameters of growth traits in Nigeria Sahelian goats. *Research Journal of Animal Science*, 2(3): 83-86.

Oyediji, D.G., Akusu, M.O., Egbunike, G.N. (1990). Comparative studies on the effectiveness of Sil-oestrus implants, Veramix sheep sponges and prostaglandin $F_2\alpha$ in synchronising oestrus in West African dwarf sheep. *Theriogenology*, 34(3): 613–618.

Oyedipe, E.O., Pathiraja, N., Edqvist, L.E. and Buvanendran, V. (1986). Onset of puberty and oestrous cycle phenomenon in Yankasa ewes as monitored by plasma progesterone concentrations. *Animal Reproduction Science,* 12: 195 – 199.

Oyeyemi, M.O., Akusu, M.O. and Adeniji, D.A. (2011). Comparative responses of West African Dwarf goats to three oestrus synchronising agents. *Journal of Commonwealth Veterinary Association,* 27(2): 214 (Abstract).

Oyeyemi, M.O., Akusu, M.O. and Adeniji, D.A. (2012). Comparative responses of West African Dwarf goats to three oestrus synchronising agents. *Israel Journal of Veterinary Medicine,* 67(1): 48-54.

Ozawa, M., Tabayashi, D., Lateif, T.A., Shimizu, T., Oshima, I. and Kanai, Y. (2005). Alterations in follicular dynamics and steroidogenic abilities induced by heat stress during follicular recruitment in goats. *Reproduction*, 129: 61-63.

Ozung, P.O., Nsa, E.E., Ebegbulem, V.N. and Ubua, J.A. (2011). The potentials of small ruminant production in Cross river rain forest zone of Nigeria: A review. *Continental Journal of Animal and Veterinary Research*, 3(1): 33 - 37.

Padilla-Rivas, G.R., Sohnrey and Holtz, W. (2005). Early pregnancy detection by real-time ultrasonography in Boer goats. *Small Ruminant Research*, 58: 87-92.

Pagot, J. (1993). *Animal Production in the Tropics and Sub-Tropics*, Macmillan, London and Basingstoke, pp. 428-432.

Palomino, J.M., McCorkell, R.B., Woodbury, M.R., Cervantes, M.P. and Adams, G.P. (2014). Ovarian super-stimulation and oocyte collection in the Wood bison *(Bison bison athabascae)* during the ovulatory season. *Theriogenology*, 81:250-256.

Paramio, M.T. and Izuierdo, D. (2014). Assisted reproduction technologies in goats. *Small Ruminants Research*, 121(1): 21-26.

Parera, B.M.A.O. (2011): Reproductive cycles of buffalo. *Animal Reproduction Science*, 124: 194–199.

Paterson, A.M., Pearce, G.P. and D'Antuono, M.F. (1991). Seasonal variation in attainment of puberty in isolated and boar-exposed domestic gilts. *Animal Reproduction Science*, 24: 323-333.

Pathiraja, N., Oyedipe, E. O., Gyang, E. O. and Obasi, A. (1991). Plasma progesterone levels during estrous cycle and their relationship with the ovulation rate in Red Sokoto goats. *British Veterinary Journal*, 147: 57-62.

Paulo, N.R.O., Galeati, G., Teixeira, D.I.A., Lopes Junior, E.S., Frietas, V.J.F. and Rondina, D. (2005). Responsiveness to progestagen-eCG-cloprostenol treatment in goats food restricted for long period and refed. *Reproduction in Domestic Animals*, 40: 108-110.

Peacock, A.J. and Hughes, P.E. (1995). The effects of daily exposure to oestrous or anoestrous gilts and sows on the attainment of puberty in the gilt. *Animal Reproduction Science*, 40:135-142.

Pearce, G.P. and Pearce, A.N. (1992). Contact with a sow in oestrus or a mature boar stimulates the onset of oestrus in weaned sows. *The Veterinary Record*, 4: 5-9.

Pedersen, L.J., Heiskanen, T. and Damm, B.I. (2003). Sexual motivation in relation to social rank in pair-housed sows. *Animal Reproduction Science*, 75: 39–53.

Pellicer-Rubio, M.T., Leboeuf, B. and Bernelas, D. (2008). High fertility using artificial insemination during deep anoestrus after induction and synchronisation of ovulatory activity by the “male effect” in lactating goats subjected to treatment with artificial long days and progestagens. *Animal Reproduction Science*, 109: 172–188.

Pellicer-Rubio, M.T., Lebeouf, B., Berneles, D., Forgerit, Y., Pougnard, J.L., Bonne, J.L., Senty, E. and Chemineau, P. (2007). Highly synchronous and fertile reproductive activity induced by the male effect during deep anestrous in lactating goats subjected to treatment with artificially long days followed by natural photoperiod. *Animal Reproduction Science*, 98: 241-258.

Peltoniemi, O.A.T., Tast, A. and Love, R.J. (2000). Factors effecting reproduction in the pig: seasonal effects and restricted feeding of the pregnant gilt and sow. *Animal Reproduction Science*, 61: 173–184.

Penna, B., Libonati, H., Director, A., Sarzedas, A.C., Matins, G., Brandao, F.Z., Fonseca, J. and Lilenbaum, W. (2013). Progestin-impregnated intravaginal sponges for oestrus induction and synchronisation influences on goats vaginal flora and antimicrobial sensitivity. *Animal Reproduction Science*, 142: 71-74.

Perera, B.M.A.O. (2011). Reproductive cycle of buffalos. *Animal Reproduction Science*, 124: 194 – 199.

Pfeiffer, K.E., Binversie, J.A., Rhinehart, J.D. and Larson, J.E. (2012). Exposure of beef females to the biostimulatory effects of bulls with or without deposition of seminal plasma prior to AI. *Animal Reproduction Science*, 133: 27–34.

Phillip, G. and Hughes, P.E. (1995). The effect of contact frequency and season on the efficacy of the boar effect. *Animal Reproduction Science*, 40: 143-150.

Pierson, J.T., Baldassarre, H. and Keefer, C.L. and Downey, B.R. (2003). Influence of GnRH administration on timing of the LH surge and ovulation in dwarf goats. *Theriogenology*, 60: 397–406.

Prado, V., Orihuela, A., Lozano, S. and Pérez-León, I. (2002). Management of the female stimulus during semen collection and its association with libido re-establishment and semen characteristics of goats. *Journal of Animal Science*, 80: 1520-1523

Prado, V., Orihuela, A., Lozano, S. and Pérez-León, I. (2003). Effect on ejaculatory performance and semen parameters of sexually-satiated male goats (*Capra hircus*) after changing the stimulus female. *Theriogenology*, 60: 261−267.

Preti, G, Wysocki, C.J., Barnhart, K.T., Sondheimer, S.J. and Leyden, J.J. (2003). Male axillary extracts contain pheromones that affect pulsatile secretion of luteinizing hormone and mood in women recipients. *Biology of Reproduction*, 68(6): 2107-2113.

Ptaszynska, M. (2009). Physiology of reproduction in mammals. In: Ptaszynska, M. (Ed): Compendium of Animal Reproduction (10^{th} revised edition). Published by Intervet International Bv, Schering-Plough Animal Health, Netherlands 2009, Pp. 11.

Rampin, O., Jérôme, N., Briant, C., Boué, F. and Maurin, Y. (2006). Are oestrus odours species specific? *Behavioural Brain Research*, 172(1): 169-172.

Rege, J.E., Toe, F., Mukasa-Mugerwa, E., Tembely, S., Anindo, D., Baker, R.I. and Laklou-Kassi, A. (2000). Reproductive characteristics of Ethiopian highland sheep. II Genetic parameters of semen characteristics and their relationships with testicular measurements in ram lambs. *Small Ruminant Research*, 39(4): 173-187.

Rekwot, P.I., Akinpelumi, O.P., Sekoni, V.O., Eduvie, L.O. and Oyedipe, E.O. (2004). Effects of nutritional supplementation and exposure to bulls on resumption of post-partum ovarian activity in Bunaji (*Bos indicus*) cattle. *The Veterinary Journal*, 167: 67-71.

Rekwot, P.I., Ogwu, D. and Oyedipe, E.O. (2000a). Influence of bull biostimulation, season and parity on resumption of ovarian activity of zebu (*Bos indicus*) cattle following parturition. *Animal Reproduction Science*, 63: 1-11.

Rekwot, P.I., Ogwu, D., Oyedipe, E.O. and Sekoni, V.O. (2001). Role of pheromones and biostimulation in animal reproduction. *Animal Reproduction Science*, 64: 1-15.

Rekwot, P.I., Ogwu, D., Sekoni, V.O. and Oyedipe, E.O. (2000b). Serum progesterone profiles of zebu cattle (*Bos indicus*) in relationship to conception and repeat breeding after artificial insemination. *Animal Reproduction Science*, 63: 41-51.

Rekwot, P.I. and Omontese, B.O. (2012). Physiology of reproduction in the female. Illustrated postgraduate lecture notes.

Rekwot, P.I., Oyedipe, E.O., Mukasa-Mugerwa, E., Sekoni, V.O., Akinpelumi, O.P. and Anyam, A.A. (1999). Fertility in zebu cattle (*Bos indicus*) after prostaglandin administration and artificial insemination. *The Veterinary Journal*, 158: 53-58.

Rekwot, P.I., Voh, Jr. A.A., Oyedipe, E.O., Opaluwa, G.I., Sekoni, V.O. and Dawuda, P.M. (1987). Influence of season on characteristics of the ejaculate from bulls in an artificial insemination centre in Nigeria. *Animal Reproduction Science,* 14: 187-194.

Reolofs, J.B., Soede, N.M, Voskamp-Harkema, W. and Kemp, B. (2008). The effect of fenceline bull exposure on expression of oestrus in dairy cows. *Animal Reproduction Science*, 108(1-2): 226-235.

Restall, B.J. (1992). Seasonal variation in reproductive activity in Australian goats. *Animal Reproduction Science*, 27: 305-318.

Restall, B.J., Restall, H. and Walkden-Brown, S.W. (1995). The induction of ovulation in anovulatory goats by oestrous females. *Animal Reproduction Science*, 40:299-303.

Riaz, H., Satter, A., Arsad, M.A. and Ahmad, N. (2012). Effect of synchronisation protocols and GnRH treatment on the reproductive performance in goats. *Small Ruminant Research*, 104: 151 – 155.

Riesenberg, S., Meinecke-Tillmann S. and Meinecke, B. (2001). Oestradiol 17-β and progesterone in the peripheral blood plasma of goats following superovulation with a single dose of pFSH, hMG or eCG. *Small Ruminant Research*, 40: 73-82.

Rincon, R.M., Arechiga, C.F., Escobar, F.J., Aguilera-Soto, J.I., Lopez-Carlos, M.A., Silva, J.M., Medina, C.A., Meza-Harrera, C.A. and Valencia, J. (2011). The male effect stimulus positively increased the ovarian and reproductive seasonality in Criollo goats irrespective of a controlled photoperiodic regime. *Journal of Applied Animal Research*, 39(3): 205 – 211.

Rivas-Muñoz, R., Fitz-Rodríguez, G., Poindron, P., Malpaux, B. and Delgadillo, J.A. (2007). Stimulation of oestrous behavior in grazing female goats by continuous or discontinuous exposure to males. *Journal of Animal Science*, 85: 1257–1263.

Rivera-Lozano, M.T., Díaz-Gómez, M.O., Urrutia-Morales, J.L., Vera-Avila, H., Gámez-Vázquez, H., Villagómez-Amezcua, M.E., Aréchiga-Flores, C.F. and Escobar-Medina, F. (2011). Seasonal variation in ovulatory activity of Nubian, Alpine and Creole x Nubian does under tropical photoperiod (22 ºN). *Tropical and Subtropical Agroecosystems*, 14: 973-980.

Rodriguez-De Lara, R., Noguez-Estranda, J., Rangel-Santos, R., Garcia-Muniz, J.G., Martinez-Hernandez, P.A., Fallas-Lopez, M. and Maldonado-Simon, E. (2000). Controlled does exposure as biostimulation of buck rabbits. *Animal Reproduction Science*, 122(3-4): 270-275.

Rodríguez-Martínez, R., Ángel-García, O., Guillén-Muñoz, J.M., Robles-Trillo, P.A., De Santiago-Miramontes, M.L, Meza-Herrera, C.A., Mellado, M. and Véliz, F.G. (2013). Oestrus induction in anoestrous mixed-breed goats using the "female-to-female effect". *Tropical Animal Health and Production*, 45(4): 911-915.

Romano, J.E. (1994a). Effects of different stimuli of service on oestrus duration in dairy goats. *Theriogenology*, 42:875-879.

Romano, J.E. (1994b). Effect of service number on oestrus duration in dairy goats. *Theriogenology*, 41: 1273-1277.

Romano, J.E. (2001). The effect of continuous presence of bucks on hastening the onset of oestrus in synchronised does during the breeding season. *Small Ruminant Research*. 30: 99-103.

Romano, J. E. (2002). Does in proestrus-oestrus hasten oestrus onset in does synchronised during the breeding season. *Applied Animal Behaviour Science*, 77: 329-334.

Romano, J.E. (2004). Synchronisation of oestrus using CIDR, FGA or MAP intravaginal pessaries during the breeding season in Nubian goats. *Small Ruminant Research***,** 55: 15–19.

Romano, J.E., Christians, C.J. and Crabo, B.G. (2000a). Continuous presence of rams hastens the onset of oestrus in ewes synchronised during the breeding season. *Applied Animal Behavioural Science*, 66: 65-70.

Romano, J.E., Crabo, B.G. and Christians, C.J. (2000b). Effect of sterile service on oestrus duration, fertility and prolificacy in artificially inseminated dairy goats. *Theriogenology* 53: 1345-1353.

Romano, J.E. and Fernandez Abella, D. (1997). Effect of service on duration of oestrus and ovulation in dairy goats. *Animal Reproduction Science*, 47: 107 - 112.

Romano, J.E., Fernendez Abella, D. and Villegas, N. (2001). A note on the effect of continuous ram presence on oestrus onset, oestrus duration and ovulation time in oestrus synchronised ewes. *Applied Animal Behavioural Science*, 73: 193-198.

Rondina, D. and Galeati, G. (2010). Nutritional effects on reproduction in small ruminants and its importance for the success of reproductive biotechnologies. *Acta Scientiae Veterinariae*, 38: 337-345.

Rosa, H.J.D. and Bryant, M.J. (2002). The ram effect as a way of modifying the reproductive activity in the ewe. *Small Ruminant Research*, 45: 1–16.

Rosa, H.J., Juniper, D.T. and Bryant, M.J. (2000a). Effects of recent sexual experience and melatonin treatment of rams on plasma testosterone concentration, sexual behaviour and ability to induce ovulation in seasonally anoestrous ewes. *Journal of Reproduction and Fertility*, 120: 169-176.

Rosa, H.J.D., Juniper, D.T. and Bryant, M.J. (2000b). The effect of exposure to oestrus ewes on rams sexual behaviour, plasma testosterone concentration and ability to stimulate ovulation in seasonally anoestrous ewes. *Applied Animal Behavioural Science*, 67: 293-305.

Rosa, H.D.J., Silva, C.C. and Bryant, M.J. (2012). The effect of melatonin treatment in rams on seasonal variation of testicular size and semen production parameters. *Small Ruminant Research*, 102: 197-201.

Roth, Z., Arav, R., Braw-Tal, A. and Wolfenson, D. (2002). Effect of treatment with follicle stimulating hormone and bovine somatotropin on the quality of oocytes aspirated in the autumn from previously heat-stressed cows. *Journal of Dairy Science*, 85: 1398-1405.

Rowe, J.D. and East, N.E. (1996). Comparison of two sources of gonadotropin for oestrus synchronisation in does. *Theriogenology*, 45: 1569 – 1996.

Rowell, J.E., Sousa, M.C. and Shipka, M.P. (2003). The male effect, mounting behavior, and the onset of estrus in farmed muskoxen. *Journal of Animal Science*, 81: 2669-2674.

Roy, K.S. and Prakash, B.S. (2009). Plasma progesterone and oestradiol-17b and total oestrogen profiles in relation to oestrus behaviour during induced ovulation in Murrah Buffalo heifers. *Journal of Animal Physiology and Animal Nutrition*, 93: 486-495.

Rubianes, E. and Menchacha, A. (2003). The pattern and manipulation of ovarian follicular growth in goats. *Animal Reproduction Science*, 78: 271-287.

Rubianes, E., Ungerfeld, R. and Menchaca, A. (2001). Avances en las técnicas de sincronización de celos en ovinos y caprinos (advances in oestrous synchronisation techniques in sheep and goats), In: *Proceedings of the IV Simposio Internacional de Reproducción Animal*. Córdoba, Argentina. Pp. 61–72.

Rural Industries Research and Development Corporation (RIRDC) (2003). Markets for skins and leather from the goat, emu, ostrich, crocodile and camel industries. *A report for the rural industries research and development corporation*, 02/142, pp 91.

Sarlos, P., Egerszegi, I., Balogh, O., Molnar, A., Cseh, S. and Ratky, J. (2013). Seasonal changes of scrotal circumference, blood plasma testosterone concentration and semen characteristics in Racka rams. *Small Ruminant Research*, 111: 90-95.

Savic, I., Berglund, H. and Lindström, P. (2005). Brain response to putative pheromones in homosexual men. *Proceedings of the National Academy of Science, United States of America,* 102: 7356−7361.

Scaramuzzi, R.J. and Martin, G.B. (2008). The importance of interactions among nutrition, seasonality and socio-sexual factors in the development of hormone-free methods for controlling fertility. *Reproduction in Domestic Animals*, 43(2): 129-136

Schwartz, T. and Wieerchos, E. (2000). Relationship between FSH and ovarian follicular dynamics in goats during the oestrous cycle. *Theriogenology*, 53: 381- 387.

Silva, P.J., Juengel, J.L., Rollyson, M.K. and Niswender, G.D. (2000). Prostaglandin metabolism in the ovine corpus luteum: catabolism of prostaglandin $F_{2\alpha}$ ($PGF_{2\alpha}$) coincides with resistance of the corpus luteum to $PGF_{2\alpha}$. *Biology of Reproduction*, 63: 1229–1236.

Silva, L.M., Rondina, D., Araújo, A.A., Sargentini, C., Lima, M.T., Rodrigues, M.R.C., Souza, A.L., Giorgetti, A., Oliveira, C.H.A. and Rodrigues, F.V. (2011). Reproductive responses and progesterone levels of postpartum oestrus synchronisation in goats with different body reserves. *Italian Journal of Animal Science,* 10: 160 – 164.

Silvestre, M.A., Salvador, I., Sánchez, J.P. and Gómez, E.A. (2004). Effect of changing female stimulus on intensive semen collection in young Murciano-Granadina male goats. *Journal of Animal Science,* 82: 1641 – 1645.

Simela, L. and Merkel, R. (2008). The contribution of chevon from Africa to global meat production. *Meat Science*, 80: 101-109.

Simoes, J. (2015). Recent advances on synchronisation of ovulation in goats, out of season, for a more sustainable production. *Asian Pacific Journal of Reproduction*, 4(2): 157-165.

Simonetti, L., Blanco, M.R. and Gardon, J.C. (2000). Oestrus synchronisation in ewes treated with sponges impregnated with different doses of medroxyprogesterone acetate. *Small Ruminant Research,* 38: 243 - 247.

Singh, D., Sharma, M.K. and Pandey, R.S. (1999). Biochemical and hormonal characterization of follicles from follicular and luteal phase ovaries of goat and sheep. *Indian Journal of Experimental Biology*, 37: 434 – 438.

Soede, N.M., Laurenssen, B., Abrahamse-Berkeveld, M., Gerritsen, R., Dirx-Kuijken, N., Langendijk, P. and Kemp, B. (2012). Timing of lactational oestrus in intermittent suckling regimes: consequence for sow fertility. *Animal Reproduction Science*, 130(1-2): 74-81.

Song, H.B., Jo, I.H. and Sol, H.S. (2006): Reproductive performance of Korean native goats under natural and intensive conditions. *Small Ruminant Research*, 65: 284-287.

Sousa, F.C., Melo, C.H.S., Filho, A.C.A.T., Avelar, S.R.G., Moura, A.A.A., Martins, J.A.M., Freitas, V.J.F. and Teixeira, D.I.A. (2011). Ovarian follicular response to different hormonal stimulation treatments in Caninde goats. *Animal Reproduction Science,* 125: 88 – 93.

Spahr, L.I. (2005). Body condition scoring in meat goats. *Penn State College of Agricultural Science*, 23: 11-15.

Sterning, M. (1995). Oestrus symptoms in primiparous sows. 2. Factors influencing the duration and intensity of external oestrous symptoms. *Animal Reproduction Science*, 40: 165-174.

Stumpf, T.T., Wolfe, M.W., Roberson, M.S., Kittok, R.J. and Kinder, J.E. (1993). Season of the year influences concentration and pattern of gonadotropins and testosterone in circulation of the bovine male. *Biology of Reproduction*, 49: 1089−1095.

Taiwo, B.B.A., Buvanendran, V. and Adu, I.F. (2005). Effects of body condition on the reproductive performance of Red Sokoto goats. *Nigerian Journal of Animal Production*, 32(1): 1 - 6.

Tanaka, T., Yamaguchi, T., Kamomae, H. and Kaneda, Y. (2003). Nutritionally induced body weight loss and ovarian quiescence in Shiba goats. *Journal of Reproduction and Development*, 49: 113-119.

Tanaka, T., Fujiwara, K.I., Kim, S., Kamomae, H. and Kaneda, Y. (2004). Ovarian and hormonal responses to a progesterone-releasing controlled internal drug releasing treatment in dietary-restricted goats. *Animal Reproduction Science*, 84: 135-146.

Tanavots, A., Kaart, T. and Saveli, O. (2002). Artificial insemination in pig breeding in Estonia. *Veterinarija ir Zootechnika*, 19: 109-111.

Tast, A., Peltoniemi, O.A., Virolainen, J.V. and Love, R.J. (2002). Early disruption of pregnancy as a manifestation of seasonal infertility in pigs. *Animal Reproduction Science*, 74: 75−86.

Tauck, S.A. and Berardinelli, J.G. (2007). Putative urinary pheromone of bulls involved with breeding performance of primiparous beef cows in a progestin-based oestrous synchronisation protocol. *Journal of Animal Science*, 85: 1669−1674.

Terry, R., Kind, K.L., Hughes, P.E., Kennaway, D.J., Herde, P.J. and van Wettere, W.H. (2013). Split weaning increases the incidence of lactation oestrus in boar-exposed sows. *Animal Reproduction Science*, 142(1-2): 48-55.

Terry, R., Kind, K.L., Weaver, A.C., Hughes, P.E. and van Wettere, W.H.E.J. (2015). Optimal timing of boar exposure relative to parturition for stimulation of lactation oestrus. *Livestock Science*, 177: 181–188.

Theodosiadou, E., Goulas, P., Kouskoura, Th. and Smokovitis, A. (2004). Oestrogen and progesterone concentrations in plasma and oviductal tissue of ewes exhibiting a natural or induced oestrus. *Animal Reproduction Science*, 80: 59–67.

Thiery, J.C., Chemineau, P., Hernandez, X., Migaud, M. and Macpaux, B. (2002). Neuroendocrine interactions and seasonality. *Domestic Animal Endocrinology*, 23: 87-100.

Thimonier, J., Cognié, Y., Lassoued, N. and Khaldi, G. (2000). L'effet mâle chez les ovins: une technique actuelle de maîtrise de la reproduction. *INRA Productions Animales*, 13: 223-231.

Thompson, L.H. and Sevege, J.S. (1978). Age at puberty and ovulation in gilts in confinement as influenced by exposure to a boar. *Journal of Animal Science*, 47: 1141-1146.

Thompson, J.G.E., Simpson, A.C., James, R.W. and Tervit, H.R. (2004). The application of progesterone-containing CIDR devices to superovulated ewes. *Theriogenology*, 33: 1297-1304.

Tummaruk, P., Tantasuparuk, W., Techakumphu, M. and Kunavongkrit, A. (2004). Effect of season and outdoor climate on litter size at birth in purebred Landrace and Yorkshire sows in Thailand. *Journal of Veterinary Medical Science*, 66: 477–482.

Tummaruk, P., Tantasuparuk, W., Techakumphu, M. and Kunavongkrit, A. (2007). Age, body weight and backfat thickness at first observed oestrus in crossbred Labdrace × Yorkshire gilts, seasonal variations and their influence on their subsequent reproductive performance. *Animal Reproduction Science*, 99: 167–181.

Ungerfeld, R. (2005). Sixty years of the ram effect (1944-2004): how we have learned what we know about it? *Journal of Animal and Veterinary Advances*, 4: 698-701.

Ungerfeld, R. (2007). Socio-sexual signaling and gonadal function. Opportunities for reproductive management in domestic ruminants. *Reproduction and Fertility*, 64: 207- 221.

Ungerfeld, R. (2009). Short-term exposure of high body weight heifers to testosterone-treated steers increases pregnancy rate during a late autumn-early winter natural service. *Animal Reproduction*, 6(3): 446 - 449.

Ungerfeld, R. (2011). Combination of the ram effect with $PGF_{2\alpha}$ oestrous synchronisation treatments in ewes during the breeding season. *Animal Reproduction Science*, 124: 65 - 68.

Ungerfeld, R., Forsberg, M. and Rubianes, E. (2004). Overview of the response of anoestrus ewes to the ram effect. *Reproduction, Nutrition and Development*, 16: 479 - 490.

Ungerfeld, R., Pinczak, A., Forsberg, M. and Rubianes, E. (2002). Ovarian responses of anoestrous ewes to the "ram effect". *Canadian Journal of Animal Science*, 82: 599 - 602.

Ungerfeld, R., Ramos, M.A and Bielli, A. (2007). Relationship between male–male and male–female sexual behavior in 5–6-month-old male lambs. *Animal Reproduction Science*, 100: 385–390.

Ungerfeld, R., Ramos, M.A. and Gonzalez-Pensado, S.P. (2008). Ram effect: Adult rams induce a greater reproductive response in anestrous ewes than yearling rams. *Animal Reproduction Science,* 103: 271–277.

Ungerfeld, R., Ramos, M.A. and Möller, R. (2006). Role of the vomeronasal organ on ram's courtship and mating behaviour, and on mate choice among oestrous ewes. *Applied Animal Behaviour Science,* 99(3): 248-252.

Ungerfeld, R., Suarez, G., Carbajal, B., Silva, L., Laca, M., Forsberg, M. and Rubaines, E. (2003). Medroxyprogesterone priming and response to the ram effect on Corriedale ewes during the non-breeding season. *Theriogenology*, 60: 35 - 45.

van Rensburg, S.J. (1971). Reproductive physiology and endocrinology of normal and habitually-aborting Angora goats. *Onderstepoort Journal of Veterinary Research*, 38: 1-62.

van Rooyen, J.A. (2013). The male effect in sheep and goats. *Grootfontein Agric*, 13(1): 1.

van Wettere, W.H.E.J., Revell, D.K., Mitchell, M. and Hughes, P.E. (2006). Increasing the age of gilts at first boar contact improves the timing and synchrony of the pubertal response but does not affect potential litter size. *Animal Reproduction Science*, 95: 97–106.

Vasques, M.I., Cavaco-Gonçalves, S., Marques, C.C., Barbas, J.P., Baptista, M.C., Cunha, T.P. and Horta, A.E.M. (2006). The effect of ram exposure previous to progestagen oestrus synchronisation on *corpus luteum* function and fertility in crossbred ewes. *EAAP publication*, 119: 343-348.

Vázquez, R. and Orihuela, A. (2001). Effect of vaginal mucus and urine from ewes in oestrus on plasma testosterone levels and weight gain of feedlot rams. *Small Ruminant Research,* 42: 173−177.

Veliz, F.G. Meza-Harrera, C.A., De Santiago-Miramontes, M.A., Arrelano-Rodriguez, G., Leyva, C., Rivas-Munoz, R. and Mellado, M. (2009). Effect of parity and progestagen priming on induction of reproductive function in Saanen goats by male exposure. *Livestock Science*, 125: 261-265.

Veliz, F.G. Moreno, S., Duarte, G., Vielma, J., Chemineau, P., Poindron, P., Malpaux, B. and Delgadillo, J.A. (2002). Male effect in seasonally anovulatory lactating goats depends on the presence of sexually active bucks, but not oestrus females. *Animal Reproduction Science,* 72: 197-207.

Veliz, F.G., Poindron, P., Malpaux, B. and Delgadillo, J.A. (2006). Maintaining contact with bucks does not induce refractoriness to the male effect in seasonally anoestrous female goats. *Animal Reproduction Science,* 92: 300-309.

Veliz, F.G., Veliz, L.I., Flores, J.A., Duarte, G., Poindron, P., Malpaux, B. and Delgadillo, J.A. (2004). La presencia del macho en un grupo de cabras anestricas no impide su respuesta estral a la introduccion de un Nuevo macho. *Vet Mex,* 54: 169-178.

Vielma, J., Chemineau, P., Poindron, P., Malpaux, B. and Delgadillo, J.A. (2009). Male sexual behavior contributes to the maintenance of high LH pulsatility in anoestrous female goats. *Hormonal Behaviour*, 56: 444 – 449.

Vielma, J., Hernandez, H., Veliz, F.G., Flores, J.A., Duarte, G. and Malpaux, B. (2005). Buck vocalizations stimulate oestrus behaviour in seasonally anoestrous anovulatory female goats. *Reproduction in Domestic Animals,* 40: 360 - 367.

Vielma, J., Martínez-Alfaro, J., Hernández, H., Flores, J., Duarte, G. and Fitz-Rodríguez, G. (2013). The sexual behaviour of the male is necessary to induce the preovulatory surge in seasonally anovulatory goats. *Reproduction in Domestic Animals*, 48(1): 113.

Vilarino, M., Rubianes, E. and Menchaca, A. (2013). Ovarian responses and pregnancy rate with previously used intravaginal progesterone releasing devices for fixed-time artificial insemination in sheep. *Theriogenology,* 79: 206-210.

Vilarino, M., Rubianes, E., van Lier, E. and Menchaca, A. (2010). Serum progesterone concentrations follicular development and time of ovulation using a new progesterone releasing device (DICO®). *Small Ruminant Research,* 91: 219-224.

Villagrán, M. and Ungerfeld, R. (2013). Permanent contact with females increases testosterone and improves fresh semen traits in pampas deer (Ozotoceros bezoarticus) males. *Animal Reproduction Science,* 143: 85 - 90.

Vinoles, C., Forsberg, M., Martin, G.B., Cajarville, C., Repetto, J and Meikle, A. (2005). Short-term nutritional supplementation of ewes in low body condition affects follicle development due to an increase in glucose and metabolic hormones. *Reproduction,* 129: 299–309.

Viudes, M.P., Cortell, C., Mocé, E., Marco-Jiménez, F., Joly, T. and Vicente, J.S. (2007). Effect of recombinant gonadotropins on embryo quality in super-ovulated rabbit does and immune response after repeated treatments. *Reproduction in Domestic Animals*, 27(3): 161 - 168.

Wakabayashi, Y., Iwata, E., Kikusui, T., Takeuchi, Y. and Mori, Y. (2000). Regional differences of pheromone production in the sebaceous glands of castrated goats treated with testosterone. *Journal of Veterinary Medical Science*, 62: 1067–1072.

Wakabayashi, Y., Mori, Y., Ichikawa, M., Yamazaki, K. and Hagino-Yamagishi, K. (2002). A putative pheromone receptor gene is expressed in two distinct olfactory organs in goats. *Chemical Senses*, 27: 207–213.

Walkden-Brown, S.W., Martin, G.B., and Restall, B.J. (1999). Role of male-female interaction in regulating reproduction in sheep and goats. *Journal of Reproduction, Fertility and Development*, 5: 243-257.

Walkden-Brown, S.W., Restall, B.J., Norton, B.W. and Scaramuzzi, R.J. (1994b). The 'female effect' in Australian cashmere goats: effect of season and quality of diet on the LH and testosterone response of bucks to oestrus does. *Journal of Reproduction and Fertility*, 100: 521-531.

Walkden-Brown, S.W., Restall, B.J., Norton, B.W., Scaramuzzi, R.J. and Martin, G.B. (1994a). Effect of nutrition on seasonal patterns of LH, FSH, and testosterone concentration, testicular mass, sebaceous gland and odour in Australian Cashmere goats. *Journal of Reproduction and Fertility*, 102: 351–360.

Waziri, M.A., Ribadu, A.Y. and Sivachelvan, N. (2010). Changes in the serum proteins, hematological and some serum biochemical profiles in the gestation period in the Sahel goat. *Veterinarski Arhiv*, 80(2): 215-224.

Wheaton, J.E., Carlson, K.M., Windels, H.F. and Johnson, L.J. (1993) CIDR-a new progesterone-releasing intravaginal device for induction of estrus and cycle control in sheep and goats. *Animal Reproduction Science*, 33: 127-141.

Whitley, N.C. and Jackson, D.J. (2004). An update on oestrus synchronisation in goats: A minor species. *Journal of Animal Science*, 82: 270-276.

Wildeus, S. (2008). Reproductive management of the meat goat. Goatworld (© 1999 – 2008 Goatworld.com). Retrieved on the 2nd of October, 2013 from http://www.goatworld.com

Wildeus, S. (2010). Current concepts in synchronisation of oestrus: Sheep and goats. *Journal of Animal Science*, 77: 1-14

Wilson, R.T. (1991). Small animal production and small ruminant resource in tropical Africa. FAO Animal Production and Health Paper 88. FAO, United Nations, Rome, pp. 6 – 26.

Willenburg, K.L., Knox, R.V. and Kirkwood, R.N. (2004). Effect of oestrogen formulation and its site of deposition on serum PGFM concentrations, uterine contractility, and time of ovulation in artificially inseminated weaned sows. *Animal Reproduction Science*, 80(1-2): 147-156.

Willis, H.J., Zak, L.J. and Foxcroft, G.R. (2003). Duration of lactation, endocrine and metabolic state, and fertility of primiparous sows. *Journal of Animal Science*, 81: 2088 – 2102.

Wuliji, T., Litherland, A., Goetsch, A.L., Sahlu, T., Puchala, R., Dawson, L.J. and Gipson, T. (2003). Evaluation of melatonin and bromocryptin administration in Spanish goats. I. Effect on the out of season breeding performance in spring, kidding rate and fleece weight of does. *Small Ruminant Research*, 49: 31–40.

Wyatt, T.D. (2009). Fifty years of pheromones. *Nature*, 457(15): 262-263.

Yildiz, S., Saatci, M., Uzun, M. and Güven, B. (2003). Effects of ram introduction after the second prostaglandin $F_{2\alpha}$ injection on day 11 on the LH surge characteristics in fat-tailed ewes. *Reproduction in Domestic Animals*, 38: 54-57.

Zahraddeen, D., Butswat, I.S.R. and Mbap, S.T. (2007). Gestation length, kidding interval and reproductive problems in goats in Bauchi. *Nigerian Journal of Agricultural Research and Policies*, 2(4): 11-16.

Zahraddeen, D., Butswat, I.S.R. and Mbap, S.T. (2008). Evaluation of some factors influencing growth performance of local goats in Nigeria. *African Journal of Food, Agriculture, Nutrition and Development*, 8(4): 464-479.

Zak, L., Foxcroft, G., Aherne, F. and Kirkwood, R. (2008). Role of luteinizing hormone in primiparous sow responses to split weaning. *Reproduction in Domestic Animals*, 43(4): 445-450.

Zakari, A.Y., Molokwu, E.C.I. and Osori, D.I.K (1981). Effect of season on oestrous cycle of cows (*Bos indicus*) indigenous to Northern Nigeria. *The Veterinary Record*, 12: 213-215.

Zarazaga, L.A., Gatica, M.C., Celi, I., Guzman, J.I. and Malpaux, B. (2011). Artificial long days and daily contact with bucks induce ovarian but not oestrus activity during the non-breeding season in Mediterranean goat females. *Animal Reproduction Science*, 125: 83-87.

Zarazaga, L.A., Gatica, M.C., Gallego-Calvo, L., Celi, I. and Guzmán, J.L. (2014). The timing of oestrus, the preovulatory LH surge and ovulation in Blanca Andaluza goats synchronised by intravaginal progestagen sponge treatment is modified by

season but not by body condition score. *Animal Reproduction Science*, 146 (3-4): 170-175.

Zarazaga, L.A., Guzman, J.L., Domınguez, C., Perez, M.C. and Prieto, R. (2005). Effect of plane of nutrition on seasonality of reproduction in Spanish Payoya goats. *Animal Reproduction Science*, 87: 253-267.

Zarazaga, L.A., Guzman, J.L., Domınguez, C., Perez, M.C. and Prieto, R. (2009). Effect of season and feeding level on reproductive activity and semen quality in Payoya goats. *Animal Reproduction Science*, 71: 1316-1325.

Zarco, L., Rodriguez, E.F., Angulo, M.R.B. and Valencia, J. (1995). Female to female stimulation of ovarian activity in the ewe. *Animal Reproduction Science*, 39: 251-258.

Zarkawi, M. (2000). The evaluation of two doses of prostaglandin $F_{2\alpha}$ analoque, Prosolvin, for oestrus synchronisation of Syrian Awassi ewes. *New Zealand Journal of Agricultural Research*, 43: 509 – 514.

Zarkawi, M. (2001). Oestrus synchronisation and twinning rate of Syrian Awassi ewes treated with progestagen and PMSG during the breeding season. *New Zealand Journal of Agricultural Research*, 44: 159 – 163.

Zeicik, A., Tilton, J.E. and Williams, G.L. (1981). Effect of mating on the luteinising hormone surge in the pig. *Journal of Animal Science*, 53: 434-438.

APPENDICES

Appendix I: Distribution of Sahel goats in Nigeria.



Source: Blench, 1999.

Appendix II: Distribution of Red Sokoto goats in Nigeria.



Source: Blench, 1999.

Appendix III: ELISA procedure for determination of serum progesterone concentration.

1. Format the microplate wells for each serum reference calibrator, control and patient specimen to be assayed in duplicates.
2. Pipette 0.025 mL (25 µL) of the appropriate serum reference calibrator, control or specimen into the assigned well.
3. Add 0.050 mL (50 µl) of Progesterone Enzyme Reagent to all wells.
4. Swirl the microplate gently for 10-20 second to mix.
5. Add 0.050 mL (50 µl) Progesterone Biotin Reagent to all wells.
6. Swirl the microplate gently for 10-20 seconds to mix. Cover and incubate for 60 minutes at room temperature.
7. Discard the contents of the microplate by decantation or aspiration. If decanting, blot the plate dry with absorbent paper.
8. Add 0.350 mL (350 µL) of wash buffer, decant or aspirate. Repeat two additional times for a total of three washes.
9. Add 0.100 mL (100 µL) of Substrate solution to all wells. Incubate at room temperature for twenty minutes. Add 0.050 mL (50 µl) of stop solution to each well and gently mix for 15-20 seconds.
10. Read the absorbance of each well at 450 nm wavelength of 620-630 nm. Record the absorbance obtained from the printout of the microtitre reader.
11. Plot the absorbance for each duplicate serum reference versus the corresponding progesterone concentration in ng/ml on linear graph paper. Connect the points with a best-fit curve.
12. To determine the concentration of progesterone for an unknown, locate the average absorbance of the duplicates for each unknown on the vertical axis of the graph, find the intersecting point on the curve, and read the concentration for the horizontal axis of the graph.