UNIVERSITI PUTRA MALAYSIA

ESTRUS, OVULATION TIME AND PREGNANCY RATE RESPONSES TO TWO ESTRUS SYNCHRONIZATION PROGRAMS IN BEEF CATTLE

KHUMRAN ARMIYA'U MADA

FPV 2012 33

ESTRUS, OVULATION TIME AND PREGNANCY RATE RESPONSES TO TWO ESTRUS SYNCHRONIZATION PROGRAMS IN BEEF CATTLE

BY

KHUMRAN ARMIYA'U MADA

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in partial Fulfilment of the Requirements for the Degree of Master of Veterinary Science

April 2012

DEDICATION

This thesis is specifically dedicated to my beloved father, Alhaji Armiya'u Mada, mother, Hajiya Aishatu A. Mada for their patience, encouragement and understanding in my interest to pursue postgraduate education in veterinary medicine and to my country at large.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in partial fulfilment of the Requirements for the degree of Master of Veterinary Science

ESTRUS, OVULATION TIME AND PREGNANCY RATE RESPONSES TO TWO ESTRUS SYNCHRONIZATION PROGRAMS IN BEEF CATTLE

BY

KHUMRAN ARMIYA'U MADA

April 2012

Chairperson : Assoc. Prof. Rosnina Haji Yusoff, PhD

Faculty : Veterinary Medicine

The aim of the study was to compare the estrus response, ovulation time and pregnancy rates of Kedah-Kelantan (KK) and Brangus (BR) cattle in Malaysia to progesterone- (P_4) and prostaglandin ($PGF_{2\alpha}$) -based estrus synchronization programs. Forty Kedah-Kelantan (KK) and 30 Brangus (BR) cows, were selected and randomly divided equally into two groups per breed. Cows in KK1 and BR1 groups received 2 ml intramuscular (i.m) injection of estradiol benzoate (Cidirol®, 1 mg/ml) at the time CIDR® was inserted into the vagina (Day 0), i.m injection of 1 ml cloprostenol (250µg/ml) at the time of CIDR® removal (Day 9) and 1 ml injection of Cidirol® (Day 10). On the other hand, cows in groups KK2 and BR2 were given $PGF_{2\alpha}$ -based treatment. Intramuscular injection of 2 ml (Day 0) and 1ml (Day 11) of Estrumate® (250 µg/ml of cloprostenol), 11 days apart in each cow. All cows were observed for estrus signs and their ovaries scanned for ovulation, followed by AI upon detection of estrus. Pregnancy status was diagnosed 45 days after AI. The present study showed that both treatments (P_4- and $PGF_{2\alpha}$-based) were effective in inducing observable estrus signs in all groups with

synchrony of ovulation resulting in corpus luteum (CL) development and successful pregnancy in all groups. In the CIDR group, 84.2% and 78.8% of KK and BR cows respectively responded to the treatment. In the $PGF_{2\alpha}$-based protocol, 80.0% of KK exhibited estrus compared with 50.0% BR cows that showed estrus. There were no significant differences in rate of ovulation and pregnancy among the four experimental groups ($P > 0.05$). However, KK had the higher rate of ovulation over BR: 84.2 vs. 64.3% and 70.0 vs. 42.9% in CIDR and $PGF_{2\alpha}$ treatments respectively. The same also holds for the pregnancy rate in KK cows, which produced the higher rate than BR, 31.6 vs. 14.3% for CIDR, and 45.0 vs. 21.4% for $PGF_{2\alpha}$, respectively. The interval from the last treatment to ovulation time varied significantly in these experiments across all groups. The highest median time to ovulation was achieved by BR cows treated with $PGF_{2\alpha}$ (84h) and the same BR cows also ovulated the earliest (48h) when treated with CIDR. These variations could be explained by the difference in ovarian status at the time of treatment. In conclusion, the results of this study showed no significant difference between the use of CIDR and $PGF_{2\alpha}$ to induce synchronization of estrus in both KK and BR.

Key words: Kedah-Kelantan, Brangus, estrus, synchronization, CIDR, $PGF_{2\alpha}$, pregnancy and ovulation.

Abstrak tesis ini disediakan untuk senat Universiti Putra Malaysia sebagai memenuhi syarat Ijazah Master Sains Veterinar

ESTRUS, OVULASI MASA DAN BALASAN KADAR KEHAMILAN UNTUK DUA PROGRAM PENYEGERAKAN ESTRUS DALAM LEMBU PEDAGING

Oleh

KHUMRAN ARMIYA'U MADA

April 2012

Pengerusi : Prof. Madya Rosnina Haji Yusoff, PhD

Fakulti : Perubatan Veterinar

Matlamat kajian ini adalah untuk membanding gerakbalas estrus dan kadar pengovulan dan kadar kebuntingan dua baka lembu pedaging di Malaysia apabila menjalani program penyelarasan estrus berasaskan progesteron dan prostaglandin. 40 ekor lembu Kedah-Kelantan (KK) dan 30 ekor lembu Brangus (BR) telah dipilih dan dibahagikan sama rata kepada dua kumpulan mengikut baka. Kumpulan KK1 dan BR1 telah disuntik intraotot 2 ml melalui estradiol benzoate (Cidirol®, 1 mg/ml) pada hari pertama CIDR dimasukkan ke dalam vagina, dan 1 ml cloprostenol semasa CIDR dikeluarkan pada hari ke-9 dan 1 ml estradiol benzuate pada hari ke-10 melalui suntikan intraotot. Kumpulan KK1dan BR1 masing-masing telah dirawat dengan 2 ml dan 1 ml suntikan intraotot cloprostenol pada jarak 11 hari. Semua lembu dicerap untuk tanda estrus dan diimbas dengan ultrabunyi untuk masa pengovulan, dan diikuti dengan AI berikutan pengesanan estrus. Status kebuntingan didiagnosis 45 hari selepas AI. Kajian ini menun jukkan kedua-dua rawatan adalah berkesan dalam mendorong estrus tercerap dengan

sinkroni pengovulan untuk perkembangan korpus luteum dan kejayaan kebuntigan bagi semua kumpulan. Bagi kumpulan CIDR, 84.2% lembu KK vs. 78.8% lembu BR telah memberi gerakbalas terhadap pensinkronan tersebut. Untuk $PGF_{2\alpha}$, bilangan lembu KK yang bergerakbalas balas adalah paling tinggi (80.0%) berbanding dengan BR (50.0%). Walau bagaimanapun tidak terdapat perbezaan signifikan pada kadar pengovulan dan kebuntingan bagi kesemua kumpulan. Namun demikian, KK menunjukkan kadar pengovulan tertinggi berbanding BR 84.2 vs. 64.3% dan 70.0 vs. 42.9% mengulangi rawatan CIDR dan $PGF_{2\alpha}$. Keadaan yang sama berlaku untuk kadar kebuntingan dimana 31.6% lembu KK bunting berbanding 14.3% BR untuk CIDR dan 45.0% KK vs. 21.4% BR untuk $PGF_{2\alpha}$. Jarak daripada rawatan terakhir ke pengovulan berbeza secara signifikan bagi kesemua kumpulan. Median masa tertinggi untuk pengovulan dicapai oleh BR yang dirawat dengan $PGF_{2\alpha}$ (84jam), begitu juga untuk pengovulan terawal (48 jam) apabila dirawat dengan CIDR. Perbezaan ini boleh diterangkan melalui perbezaan pada status ovari pada masa rawatan. Kesimpulannya, hasil daripada data ini menunjukkan tiada perbezaan signifikan antara penggunaan CIDR mahupun $PGF_{2\alpha}$ dalam mendorong pensinkronian estrus bagi kedua-dua kumpulan KK dan BR.

Kata kekunci: Kedah-Kelantan, Brangus, estrus, pensinkronian, CIDR, $PGF_{2\alpha}$, kebuntingan, pengovulan.

ACKNOWLEDGEMENTS

As the English saying goes, one hand cannot claps. It would be impossible for me to undertake this research project alone without input/contributions from others, to which much credit and my heartfelt thanks are owed. Firstly, to the Almighty Allah that gave me the ability and courage to withstand all the challenges throughout the study.

Special thank goes to my able supervisor, Assc. Prof. Dr. Rosnina Haji Yusoff, for her valuable concern, guidance and kind support throughout this research work. Her guidance and assistance motivated me to achieve this unforgetful victory. I must extend my thankfulness to members of my supervisory team: Professor Dr. Abd Wahid Haron, Assoc. Prof. Dr. Gurmeet Kaur Dhaliwal and Professor Dr. Mohamed Ariff Omar for their kind suggestions, guidance and assistance throughout my Master's program. To my father, mother, stepmothers, brothers, sisters, wife and children, thank you for all the cash and kind support that you have given to me. All your sacrifices in order to make sure my dream come true are appreciated. May God reward you for it.

I would also like to express my gratitude to all the academic, technical staff and students of the Faculty of Veterinary Medicine, UPM who contributed immensely to the success of this great achievement. Mr. Yap Keng Chee., Mr. Fahmi Mohd Mashuri, Mr. Perumal Ganesamurthy, Mr. Zaid Othman, Bashir M. Sani, Dr. Nurhusein, Bukar, Malik, Punckhanh, Ibrahim Anka, Faruk Bande, Marwan Abofila, Mukhtar Anka. Thank you

all for your assistance and advice. Appreciation also goes to all of my friends and associates both home and abroad that have been there for me tirelessly all the time. To mention but a few; Mal Bala Adamu, Dr. Umar Adamu, Br. Almustapha Y. Mada, Abubakar Umar, Musa Zuru, Sani Sadiq Alkali, Dr. Kabiru Bungudu, Tijani Abubakar and Abubakar Salihu Mafara. Finally, many thanks go to the staff of the Kelantan farm, UPM farm and the Institute of National Institute of Veterinary Biodiversity Jerantut, Pahang. Malaysia.

I certify that a Thesis Examination Committee has met on 30 April 2012 to conduct the final examination of Khumran Armiya'u Mada on his thesis entitled "Estrus, Ovulation Time and Pregnancy Rate Responses to Two Estrus Synchronization Programs in Beef Cattle" in accordance with the Universities and University Colleges Act 1971 and the constitution of the Universiti Putra Malaysia, [P. U. (A) 106] 15 March 1998]. The committee recommends that the student be awarded the degree of Master of Veterinary Science.

Members of the Thesis Examination Committee are as follows:

Mohd Hair Bejo, PhD
Professor
Faculty of Veterinary Medicine
Universiti Putra Malaysia
(Chairman)

Mohamed Ali Rajion, PhD
Professor
Faculty of Veterinary Medicine
Universiti Putra Malaysia
(Internal Examiner)

Tengku Azmi Tengku Ibrahim, PhD
Professor Dato'
Faculty of Veterinary Medicine
Universiti Putra Malaysia
(Internal Examiner)

Musaddin bin Kamaruddin, PhD
Professor
Strategic Livestock Research Centre
MARDI
(External Examiner)

SEOW HENG FONG, PhD
Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 28 June 2012

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as partial fulfillment for the degree of Master of Veterinary Science. The members of the Supervisory Committee were as follows:

Rosnina Haji Yusoff, PhD
Assoc. Professor
Faculty of Veterinary Medicine
Universiti Putra Malaysia
(Chairperson)

Abd Wahid Haron, PhD
Professor
Faculty of Veterinary Medicine
Universiti Putra Malaysia
(Member)

Gurmeet Kaur Dhaliwal, PhD
Assoc. Professor
Faculty of Veterinary Medicine
Universiti Putra Malaysia
(Member)

Mohamed Ariff Bin Omar, PhD
Professor
Faculty of Veterinary Medicine
Universiti Putra Malaysia
(Member)

BUJANG BIN KIM HUAT, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

DECLARATION

I declare that the thesis is my original work except for quotations and citations, which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

KHUMRAN ARMIYA'U MADA

Date: 30 April 2012

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ADG	average daily gain
AI	artificial insemination
BCS	body condition score
BRTF	beef reproduction task force
CIDR®	Controlled Internal Drug Release
CL	corpus luteum
eCG	equine Chorionic Gonadotropin
EB	estradiol benzoate
FAMA	Federal Authority for Marketing Agency
FSH	follicle stimulating hormone
GH	growth hormone
GnRH	gonadotropin releasing hormone
H_A	alternate hypothesis
H_O	null hypothesis
IAEA	International Atomic Energy Agency
IBBA	International Brangus Breed Association America
KK	Kedah-Kelantan
LH	luteinizing hormone
MARDI	Malaysian Agricultural Research and Development Institute
MGA	melengestrol acetate
OE	onset of estrus
P_4	progesterone
$PGF_{2\alpha}$	Prostaglandin$F_{2\alpha}$
PIDR®	Progesterone Internal Drug Release
PKC	palm kernel cake

POME	palm oil mill effluent
PTHPT	Pusat Ternakan Haiwan, Pantai Timur
SAS	Statistical Analysis System
SD	Standard deviation
TPU	Taman Pertanian Universiti
UPM	Universiti Putra Malaysia

CHAPTER 1

INTRODUCTION

Beef cattle production is a crucial sector of a nation's economic development. As part of mixed crop-livestock farming, it supports small-scale farmers with employment, sustainable income and social security provisions (Boettcher and Perera, 2007). Beyond that, beef is also an important source of animal protein, which is needed for bodybuilding and growth. Beef is also a good source of certain vitamins like cyanocobalamin, thiamine and niacin, minerals such as zinc, potassium and iron. Thus, it become a necessity for human consumption. Meat consumption therefore, increases with the increase in human population resulting in increase in demand. For example, one of the consequences for the current developing economy in Asia is the rise in the demand for food, arising from animal agriculture (Boettcher and Perera, 2007).

The aforementioned increase in the demand for beef poses a challenge to the beef production industries because production efficiency depends highly on reproductive performance. Smith and Somade (1994) reported that reproductive performance of farm animals is economically 5 times more important than the growth of farm animals and even 10 times more than the product quality of these animals. Unfortunately, fertility remains a complex issue in a beef production system and it varies with breed, sex, age and location according to Cammack et al. (2009). This is making natural proliferation of the beef cattle seems difficult in keeping pace with its growing demand and thus,

resulting in the quest for improved breeding. In turn, rate of production will be accelerated and the genetic conservation of the animals will be integrated as well.

Synchronization of estrus allows for the controlled induction of a number of females into expressing estrus within a stipulated period so that handling and breeding can be planned according to the farmer's schedule and desired calving season. Estrus synchronization has greatly contributed to reducing labor cost and improved breeding through artificial insemination (AI), in order to maximize reproduction, especially in the cattle industry.

Synchronization of estrus is achieved through various methods. Some researchers have showed that breed effect exist in cattle (Landaeta-Hernández et al., 2002; Kriniger et al., 2003), where certain breeds respond better to a particular method than to another. A study by Kriniger and colleagues (2003) have shown that estrus synchrony was greater in Brahman than in Holstein cows when gonadotropin releasing hormone (GnRH) and prostaglandin F2α ($PGF_{2\alpha}$) synchronization protocols were applied. However, a proportion of the Brahmans was standing estrus than their Holstein counterpart.

Several studies have reported responses of cows to various estrus synchronization protocols with the view to identifying the method that works best for different groups of buffaloes and cattle (Neglia et al., 2003; Melendez et al, 2006; Karakok et al., 2009). Karakok and colleagues (2009) compared two different estrus synchronization methods

with fixed timed AI protocols for Holstein cows during the winter and summer seasons in the Mediterranean region. They reported that the efficiency of estrus synchronization treatment with both P_4 and $PGF_{2\alpha}$-based protocols was satisfactory during the winter season, but not in the summer months.

Artificial insemination is the one single technique that has no doubt played a pivotal role in the improvement of cattle reproductive efficiency (Foote, 2002; Vishwanath, 2003; Bearden et al., 2004). The first documented case of AI was reported in 1780 when an Italian scientist named Spallanzany successfully inseminated a bitch, which whelped 62 days later (Bearden et al., 2004). With time, AI makes it possible to inseminate a number of females with a single ejaculate, simply by extending the ejaculate. Superior germ plasma can be used in AI and propagated to improve the genetics even when the sire is dead. It also eliminates the risk of keeping an aggressive bull in the farm as well as to control the spread of venereal diseases. In order to maximize the benefits of AI, other techniques were developed that include collection, processing and storage of semen, detection and pharmacological manipulation of estrus leading to control of estrous cycle in the female animals. Moreover, AI is achieved using fresh and frozen-thawed semen.

Apart from the inseminator's skill and experience, the success of AI also depends on the proper handling of semen and processing right from collection to insemination through freezing, packing, storage and thawing. In AI, the target is always to deposit maximum

number of high quality spermatozoa into the female's reproductive tract, which will result in pregnancy.

There is very little information on estrus response comparison of the indigenous Kedah-Kelantan (KK) and the exotic Brangus (BR) in Malaysia. Although BR was introduced in the country about a decade ago and seemed to be gaining recognition in commercial beef production, there is little literature on its reproductive performance in Malaysia. Moreover, comparative reproductive responses between BR and KK has not been reported. Thus, this dearth of information formed the basis of this present research.

In view of the above statements, the responses of the two beef breeds to two protocols of estrus synchronization were studied. In addition, comparison was made on their estrus behavior, time of ovulation and pregnancy rate. Therefore, the **objectives** of the present study were:

1. To analyze the estrus response of KK and BR cows to progesterone- and prostaglandin-based estrus synchronization protocols.
2. To compare estrus behavior and ovulation time of KK and BR cows following estrus synchronization with progesterone and prostaglandin protocols.
3. To compare the pregnancy rate of the KK and BR cows after AI, following estrus synchronization by progesterone- and prostaglandin-based protocols.

Hypotheses of the study

H_O1 = There is no difference on estrus response between KK and BR following estrus synchronization with either P_4- or $PGF_{2\alpha}$- based protocols

H_A1 = There is a difference in estrus response between KK and BR following estrus synchronization with either P_4- or $PGF_{2\alpha}$- based protocols

H_O2 = There is no difference on ovulation time between KK and BR following estrus synchronization with either P_4- or $PGF_{2\alpha}$- based protocols

H_A2 = There is a difference in ovulation time between KK and BR following estrus synchronization with either P_4- or $PGF_{2\alpha}$- based protocols

H_O3 = There is no difference on pregnancy rate between KK and BR following estrus synchronization with either P_4- or $PGF_{2\alpha}$- based protocols

H_A3 = There is a difference in pregnancy rate between KK and BR following estrus synchronization with either P_4- or $PGF_{2\alpha}$- based protocols

Limitation

The limitation in this study was the number of non- pregnant cows used, which very much depended on their availability. As a result, the different breeds were located at different farms. This also led to the non- uniformity in the cows' age and weight.

REFERENCES

Ahmed, A. F., Mohamed, Z. A., & Harron, M. (2012). Consumer's Perception and Attitude towards Mutton Consumption in Peninsular Malaysia. Retrieved 19 May, 2012, from <http://www.agri.upm.edu.my/files/prpi_silver/Consumer%20Perception%20and%20Attitude%20towards%20Mutton%20Consumption%20in%20Peninsular%20Malaysia.pdf>

Alvarez-Rodriguez, J. & Sanz, A. (2009). Physiological and behavioural responses of cows from two beef breeds submitted to different suckling strategies. *Applied Animal Behaviour Science, 120*(1-2), 39-48.

Aman, A., Brown, C. J. & Johnson, Z. (1978). Size and shape of Kedah-Kelantan cows. *Growth*, *42*(4), 486- 494.

Ax, R. L., Dally, M. R., Didion, B. A., Lenz, R. W., Love, C. C., Varner, D. D., Hafez, B. & Bellin, M. E. (2000). *Artificial Insemination: In: Reproduction in Farm Animals* (7th ed.): Eds: Hafez & Hafez. Lippincott Williams & Wilkins. Maryland, USA. 376-389.

Bearden, H. J., Fuquay, J. W. & Willard, S. T. (2004). *Applied Animal Reproduction* (6th ed.): Pearson Prentice Hall. New Jersey, USA.1-427.

Boettcher, P. J. & Perera, B. M. A. O. (2007). *Improving the reproductive management of dairy cattle subjected to artificial insemination (AI)* IAEA.Vienna (ISSN No. 1011-4289) 1-7.

Bridges, G. A., Portillo, G. E., de Araujo, J. W., Thatcher, W. W. & Yelich, J. V. (2005). Efficacy of either a single or split treatment of $PGF_{2\alpha}$ after a 14 day melengestrol acetate treatment to synchronize estrus and induce luteolysis in Bos indicus × Bos taurus heifers. *Theriogenology, 64*(2), 344-362.

Briggs, H. M. & Briggs, D. M. (1980) *Modern Breeds of Livestock* (4th ed.): Macmillan Publishing Co. New York, USA. 1-772.

Buddenberg, B. J., Brown, C. J., Peterson, H. P. & Brown, A. H. (1989). Factors influencing pregnancy rate and calving date in four breeds of beef cows on an Ozark mountain range. *Animal Reproduction Science, 18*(4), 243- 252.

Cammack, K. M., Thomas, M. G. & Enns, R. M. (2009). Review: Reproductive traits and their heritabilities in beef cattle. *The Professional Animal Scientist* 24, 517-528.

Camoens, J. K. (1981). The indigenous Zebu of Malaysia. Ministry of Agriculture, Malaysia (Research Report No. 151), 155.

Chenault, J. R., Boucher, J. F., Dame, K. J., Meyer, J. A. & Wood-Follis, S. L. (2003). Intravaginal progesterone insert to synchronize return to estrus of previously inseminated dairy cows. *Journal of Dairy Science, 86*(6), 2039-2049.

Cyberbee (2010). *Why study honey bees?*In: Honey bee research (electronic article), 1-4. Retrieved 17/06/2010 from http:// www.cyberbee.net/research.htm.

Dalton, J. C. (1999). *Factors important to the efficiency of artificial insemination in single-ovulating and superovulated cattle.* Virginia Polytechnic Institute and State University, Blacksburg, USA. (PhD Dissertation) 1- 124.

Day, M. L. & Grum, D. E. (2005). Breeding strategies to optimize reproductive efficiency in beef herds. *Veterinary Clinics of North America: Food Animal Practice, 21*(2), 367-381.

Dees Brothers Brangus (2009). Advantages that the Brangus breed has over the English and exotic breeds. In; special qualities of Brangus Retrieved 09/09, 2011, from http://deesbrothersbrangus.com/qualities.html.

DeJarnette, M. (2004). *Estrus synchronization*: A reproductive management tool. Retrieved on 29/04/2010, from www.selectsires.com, Powered by Google docs.

Dobbins, C. A., Eborn, D. R., Tenhouse, D. E., Breiner, R. M., Johnson, S. K., Marston, T. T. & Stevenson, J. S. (2009). Insemination timing affects pregnancy rates in beef cows treated with CO-Synch protocol including an intravaginal progesterone insert. *Theriogenology, 72*(7), 1009-1016.

Dransfield, M. B. G., Nebel, R. L., Pearson, R. E., & Warnick, L. D. (1998). Timing of insemination for dairy cows identified in estrus by a radiotelemetric estrus detection System. *Journal of Dairy Science, 81*(7), 1874-1882.

DVS (2011a). Malaysia: Self-sufficiency in livestock products (%), 2000-2010. Department of Veterinary Services Malaysia: Retrieved on 06 December 2011.

DVS (2011b). Livestock population of Malaysia (2005- 2010). Department of Veterinary Services Malaysia: Retrieved on 23 May 2011, from http://www.dvs.gov.my/web/guest/perangkaan.

DVS (2012). Malaysia: Output of Livestock Products, 2000-2010. Department of Veterinary Services Malaysia: Retrieved on 19 May 2011.

Eversole, D. E., Browne, M. F., Hall, J. B. & Dietz, R. E. (2009). *Body Condition Scoring Beef Cows*. 1-6. Retrieved 06/06/2010 from http://pubs.ext.vt.edu/400/400-795/400-795.pdf.

Foote, R. H, (2002). The history of artificial insemination: Selected notes and notables. *Journal of Animal Science*, 80, 1-10.

Forde, N., Beltman, M. E., Lonergan, P., Diskin, M., Roche, J. F., & Crowe, M. A. (2011). Oestrous cycles in Bos taurus cattle. *Animal Reproduction Science, 124*(3- 4), 163-169.

Galina, C. S., & Orihuela, A. (2007). The detection of estrus in cattle raised under tropical conditions: What we know and what we need to know. *Hormones and Behavior, 52*(1), 32-38.

Ghanem, M., Isobe, N., Kubota, H., Suzuki, T., Kasuga, A. & Nishibori, M. (2008). Ovarian cyclicity and reproductive performance of holstein cows carrying the mutation of complex vertebral malformation in Japan *Reproduction in Domestic Animals, 43*(3), 346-350.

Gordon, M., Mohamed, H., Rajamahendran, R. & Dinn, N. (2008). *Comparison of two estrus synchronization protocols for fixed-time breeding to increase pregnancy in lactating dairy cows*. Research Reports. The University of British Columbia, 8(2), 1-2.

Hafez, E. S. E., Jainudeen, M. R. & Rosnina, Y. (2000). *Hormones, growth factors and reproduction. In: Reproduction in farm animals* (7th ed.). Maryland, USA: Lippincott Williams and Willkins, (33-54).

Headrick, D. (2010). *Instrumental insemination of queen bee.* Retrieved 17/06/2010, http://mustangdaily.net/artificial-insemination-of-bees-soon-to-be-at-cal-poly/.

Hemeda, H. (2005). Progestogens. In Pharmacopoeias. *Ain Shams Journal of Obstetrics and Gynecology, 2*(5), 408-410.

Heuwieser, W., Oltenacu, P. A., Lednor, A. J. & Foote, R. H. (1997). Evaluation of different protocols for prostaglandin synchronization to improve reproductive performance in dairy herds with low estrus detection efficiency. *Journal of Dairy Science, 80*(11), 2766-2774.

IBBA (1997). *Brangus. In: Breeds of livestock*. International Brangus Breeders Association (IBBA), San Antonio, TX. USA. 1-2. Retrieved on 06/06/2010 from <http://www.int-brangus.org/home.htm>.

Johnson, S. K., Funston, R. N., Hall, J. B., Kesler, D. J., Lamb, G. C., Lauderdale, J. W., Patterson, D. J., Perry, G. A. & Strohbehn, D. R. (2011). Multi-state Beef Reproduction Task Force provides science-based recommendations for the application of reproductive technologies. *Journal of Animal Science, 89*(9), 2950-2954.

Karakok, S. G., Gungor, C., Saler, M. & Ulubilir, M. (2009). The comparison of two different seasons oestrus synchronization results with fixed- timed AI protocol. *Journal of Animal and Veterinary Advances, 8(2)*, 373-378.

Kasimanickam, R., Day, M. L., Rudolph, J. S., Hall, J. B. & Whittier, W. D. (2009). Two doses of prostaglandin improve pregnancy rates to timed-AI in a 5-day progesterone-based synchronization protocol in beef cows. *Theriogenology, 71*(5), 762-767.

Kassie, G. T., Abdulai, A. & Wollny, C. (2009). Valuing traits of indegenous cow in central Ethiopia. *Journal of Agricultural Economics, 60(2)*, 386- 401.

Kiracofe, G. H., Keay, L. E. & Odde, K. G. (1985). Synchronization of estrus in cyclic beef heifers with the prostaglandin analog alfaprostol. *Theriogenology, 24*(6), 737-745.

Krininger, C. E., Block, J., Al-Katanani, Y. M., Rivera, R. M., Chase, C. C. & Hansen, P. J. (2003). Differences between Brahman and Holstein cows in response to estrus synchronization, superovulation and resistance of embryos to heat shock. *Animal Reproduction Science, 78*(1-2), 13-24.

Kuhulmann, K., K., Shelby, D., R., Scott, C., B., May, B., J. & Engdahl, G., R. (1998). The use of an electronic estrus detection system to monitor estrus brhaviour in Angus females of various ages. *Journal of Dairy Science, 81(Suppl. 1): 271(Abstr.1056), 76*, 271.

Lamb, G. C., Dahlen, C. R., Larson, J. E., Marquezini, G. & Stevenson, J. S. (2010). Control of the estrous cycle to improve fertility for fixed-time artificial insemination in beef cattle: A review. *Journal of Animal Science, 88*(13), E181-E192.

Landaeta-Hernández, A. J., Yelich, J. V., Lemaster, J. W., Fields, M. J., Tran, T., Chase, C. C., Rae, D. O. & Chenoweth, P. J. (2002). Environmental, genetic and social factors affecting the expression of estrus in beef cows. *Theriogenology, 57*(4), 1357-1370.

Lane, E. A., Austin, E. J., Roche, J. F. & Crowe, M. A. (2001). The effect of estradiol benzoate on synchrony of estrus and fertility in cattle after removal of a progesterone-releasing intravaginal device. *Theriogenology, 55*(9), 1807-1818.

Lyimo, Z. C., Nielen, M., Ouweltjes, W., Kruip, T. A. M. & van Eerdenburg, F. J. C. M. (2000). Relationship among estradiol, cortisol and intensity of estrous behavior in dairy cattle. *Theriogenology, 53*(9), 1783-1795.

Macmillan, K. L. & Burke, C. R. (1996). Effects of estrous cycle control on reproductive efficiency. *Animal Reproduction Science, 42*(1), 307- 320.

Martinez, M. F., Adams, G. P., Kastelic, J. P., Bergfelt, D. R. & Mapletoft, R. J. (2000). Induction of follicular wave emergence for estrus synchronization and artificial insemination in heifers. *Theriogenology, 54*(5), 757-769.

Melendez, P., Gonzalez, G., Aguilar, E., Loera, O., Risco, C. & Archbald, L. F. (2006). Comparison of two estrus-Synchronization protocols and timed artificial insemination in dairy cattle. *Journal of Dairy Science, 89*(12), 4567-4572.

Morrell, J., M. (1995). Artificial insemination in rabbits. *British Veterinary Journal, 151*, 477- 488.

Murugavel, K., Yaniz, J. L., Santolaria, P., Lopez-Bejar, M. & Lopez-Gatius, F. (2003). Prostaglandin based estrus synchronization in postpartum dairy cows: An update. *The International Journal of Applied Research in Veterinary Medicine*, 9(2), 1-22.

Nebel, R. L., Dransfield, M. G., Jobst, S. M. & Bame, J. H. (2000). Automated electronic system for detection of oestrus timing of AI in cattle. *Animal Reproduction Science, 60-61*, 713- 723.

Neglia, G., Gasparrini, B., Di Palo, R., De Rosa, C., Zicarelli, L. & Campanile, G. (2003). Comparison of pregnancy rates with two estrus synchronization protocols in Italian Mediterranean buffalo cows. *Theriogenology, 60*(1), 125-133.

O' Connor, M. L. (2010). *Systemic breeding program for dairy cows*. The Pennsylvania State University (Ed.), Department of Dairy and Animal Science, 1- 4.

Odde, K. G. (1990). A review of synchronization of estrus in postpartum cattle. *Journal of Animal Science, 68*(3), 817-830.

Panandam, J. M., Abdelwahid, H. H., Majidi, A. & Kit, Y. (2010). *Genetic characterisation of indigenous Kedah-Kelantan cattle and its crossbred breed types*.1-3 (electronic article). Retrieved on 06/06/2010 from http://www.biotek.gov.my/nbs2010/program/oral/ac/abstract/day2/Jothi%20Malar%20Panandam%20UPM.pdf

Patterson, D. J. & Corah, L. R. (1992). Evaluation of a melengestrol acetate and prostaglandin F2[alpha] system for the synchronization of estrus in beef heifers. *Theriogenology, 38*(3), 441-447.

Pehr, D. J. (2008). *NMSU-led research effort focuses on boosting cattle fertility*. In N. M. S. University (Ed.), 505, (635-2017): New Mexico State University.

Petersson, K. J., Gustafsson, H., Strandberg, E. & Berglund., B. (2006). Atypical progesterone profiles and fertility in Swedish dairy cows. *Journal of Dairy Science, 89*(7), 2529-2539.

Portillo, G. E., Bridges, G. A., de Araujo, J. W., Shaw, M. V., Schrick, F. N., Thatcher, W. W. & Yelich, J. V. (2008). Response to GnRH on day 6 of the estrous cycle is diminished as the percentage of Bos indicus breeding increases in Angus, Brangus, and Brahman×Angus heifers. *Animal Reproduction Science 103*(1-2), 38- 51.

Roelofs, J. B., Bouwman, E. G., Dieleman, S. J., Van Eerdenburg, F. J. C. M., Kaal-Lansbergen, L. M. T. E., Soede, N. M. & Kemp, B. (2004). Influence of repeated rectal ultrasound examinations on hormone profiles and behaviour around oestrus and ovulation in dairy cattle. *Theriogenology, 62*(7), 1337-1352.

Roelofs, J. B. (2005). *When to inseminate the cow ? Insemination, ovulation and fertilization of the dairy cattle*. Wageningen University, Wageningen, The Netherland. (PhD Dissertation) 1-152.

Roelofs, J., Lopez-Gatius, F., Hunter, R. H. F., van Eerdenburg, F. J. C. M. & Hanzen, C. (2010). When is a cow in estrus? Clinical and practical aspects. *Theriogenology,* 74 (3), 327-344.

Rosby, R. (2007). Early weaning beef calves. *Veterinary Clinics of North America: Food Animal Practice 23*(1), 29- 40.

Rushton, J., Pilling, D. & Heffernan, C. L. (2002). Appendix 7. *A literature review of livestock diseases and their importance in the lives of poor people* (pp. 1- 84). Nairobi, Kenya: International Livestock Research Institute (ILRI).

Sá Filho, O. G., Dias, C. C., Lamb, G. C. & Vasconcelos, J. L. M. (2010a). Progesterone-based estrous synchronization protocols in non-suckled and suckled primiparous Bos indicus beef cows. *Animal Reproduction Science, 119*(1-2), 9-16.

Sá Filho, M. F., Ayres, H., Ferreira, R. M., Marques, M. O., Reis, E. L., Silva, R. C. P., Rodrigues, C. A., Madureira, E. H., Bó, G. A. & Baruselli, P. S.(2010b). Equine chorionic gonadotropin and gonadotropin-releasing hormone enhance fertility in a norgestomet-based, timed artificial insemination protocol in suckled Nelore (Bos indicus) cows. *Theriogenology, 73*(5), 651-658.

Samuel, C. & Mark, T. (1984). *Beef Cattle: In Animal Production in Malaysia.*

Saumande, J. & Humblot, P. (2005). The variability in the interval between estrus and ovulation in cattle and its determinants. *Animal Reproduction Science, 85*(3-4), 171-182.

Seguin, B. E., Momont, H. W., Fahmi, H. & Tibary, A. (1989). Single appointment insemination for heifers after prostaglandin or progestin synchronization of estrus. *Theriogenology, 31*(6), 1233- 1238.

Sharif, Z. A. & Mohamed, W. (2005). *Beef production for Malaysian entrepreneurs*. Kuala Lumpur: Malaysian Agricultural Research and Development Institute (MARDI). 1-144.

Shrestha, H. K., Nakao, T., Higaki, T., Suzuki, T. & Akita, M. (2004). Resumption of postpartum ovarian cyclicity in high-producing Holstein cows. *Theriogenology, 61*(4), 637-649.

Smith, O. B. & Somade, B. S. (1994). *Nutrition reproduction interractions in farm animals*. In: International foundation seminar on animal production (January 17-21). Niamey, Niger.1-33.

Trimberger, G. W. (1948). Breeding efficiency in dairy cattle from artificial insemination at various intervals before and after ovulation. *University of Nebraska Agricultural Experiment Station Research Bulletin, 153*, 1-3.

Troxel, T. R. & Whitworth, W. A. (2010). *Synchronization of estrus in cattle*. Arkansas: pP (1-12). University of Arkansas, USA.

Van Eerdenburg, F. J., Loeffler, H. S. & van Vliet, J. H. (1996). Detection of oestrus in dairy cows: a new approach to an old problem. *Veterinary Quarterly 18*(2), 52-54.

Van Eerdenburg, F. J. C. M., Karthaus D., Taverne, M. A. M., Mercis, I. & Szenci, O. (2002). The relationship between estrous behavioral score and time of ovulation in dairy cattle. *Journal of Dairy Science, 85*(5), 1150-1156.

Verduzco, A., Galina, C. S., Rubio, I. & Maquivar, M. (2006). Average response to estrus and timing of ovulation in Bos indicus cattle synchronized alternatively with a synthetic progestagen. *Journal of Animal and Veterinary Advances, 5*(11), 924-929.

Vishwanath, R. (2003). Artificial insemination: the state of the art. *Theriogenology, 59*(2), 571-584.

Voh Jr, A. A., Larbi, A., Olorunji, S. A. S., Aguemang, K., Abiola, B. D. & Williams, T. O. (2004). Fertility of N'dama and Bunaji cattle to artificial insemination following estrus synchronization with PRID and PGF_{2alpha} in the hot humid zone of Nigeria *Tropical Animal Health and Production, 36*, 499- 511.

Warr, S., Rodriguez, G. & Penm, J. (2008). *Changing food consumption and imports in Malaysia: Opportunities for Australian agricultural exports*. Australian Bureau of Agricultural and Resource Economics (ABARE) research report 08.6 August, 2008) Canberra, 1-29.

Weems, C. W., Weems, Y. S. & Randel, R. D. (2006). Prostaglandins and reproduction in female farm animals. *The Veterinary Journal, 171*(2), 206-228.

Whisnant, C. S., Washburn, S. P. & Farin, P. W. (2000). *Current Concept in Synchronization of Estrus and Ovulation of Dairy Cows.* In Proceedings of American Society of Animal Science 1999. 1-8.

Whittier, J. C. (2012). Reproductive anatomy and physiology of the cow [monograph on the Internet] Retrieved 30/04, 2012, from http://extension.missouri.edu/p/G2015

Whitworth, W. A. (1999). *The influence of different hormone treatment and time of insemination on estrous synchronization, mating behavior and conception rate in west Texas beef cattle*. Angelo State University, USA. (Master Thesis) 1-37.

Wood-Follis, S. L., Kojima, F. N., Lucy, M. C., Smith, M. F. & Patterson, D. J. (2004). Estrus synchronization in beef heifers with progestin-based protocols: I. Differences in response based on pubertal status at the initiation of treatment. *Theriogenology, 62*(8), 1518-1528.

Yavas, Y. & Walton, J. S. (2000). Postpartum acyclicity in suckled beef cows: A review. *Theriogenology, 54*(1), 25- 55.

Yelich, J. V., Mauck, H. S., Holland, M. D. & Odde, K. G. (1995). Synchronization of estrus in suckled postpartum beef cows with melengestrol acetate and PGF_{2alpha}. *Theriogenology,43*(2),389-400.

Yimer, N., Rosnina, Y., Wahid, H., Saharee, A. A., Yap, K. C. & Ganesamurthi, P. (2010). Ovarian activity in beef and dairy cows with prolonged postpartum period and heifers that fail to conceive. *Tropical Animal Health Production, 42*(4), 607-615.

Yong, T. K. & John, E. (2004). Reviving up agriculture's growth engine. New Sunday Times 11 Jan. 2004.