UNIVERSITI PUTRA MALAYSIA

PREDICTION OF PARTURITION IN SAANEN GOATS USING MORPHOMETRY, PHYSIOLOGICAL AND BIOCHEMICAL PARAMETERS

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LIST OF ABBREVIATIONS

ACTH : Adrenocorticotropic hormone

AUC : area under curve

FAD-GDH : FAD-dependent glucose dehydrogenases

mL : milliliter

mm : millimeter

mmol/L : millimoles per liter

PGF2α : prostaglandin F2α

ROC : Receiver operating characteristic

rpm : revolutions per minute

SEM : standard error of mean

SSL : self-sufficiency level

µL : microliter

ABSTRAK

Abstrak daripada kertas projek yang dikemukakan kepada Fakulti Perubatan Veterinar untuk memenuhi sebahagian daripada keperluan kursus VPD 4999 –Projek Ilmiah Akhir Tahun.

RAMALAN BERSALIN DALAM KAMBING SAANEN MENGGUNAKAN PARAMETER MOPHOMETRI, FISIOLOGI DAN BIOKIMIA

oleh

Chew Hui San

2021

Penyelia: Dr. Mark Hiew Wen Han

Penyelia Bersama: Prof. Madya Dr. Ooi Peck Toung

Sebelum ini, para penternak bergantung kepada pemerhatian visual untuk meramalkan masa bersalin kambing betina. Walau bagaimanapun, parameter-parameter ini adalah subjektif dan tidak dapat menentukan masa bersalin dengan tepat. Oleh itu, kajian ini dijalankan untuk menentukan perubahan parameter-parameter yang diukur seperti suhu rektum, tahap kelonggaran ligamen sacrosciatic dan kepekatan glukosa darah dan kolerasinya dengan masa bersalin. Enam kambing betina yang sedang bunting berat telah digunakan dalam kajian ini. Data untuk suhu rektum, kelonggaran ligamen sacrosciatic dan kepekatan glukosa darah dikumpul setiap hari bermula daripada tiga hari sebelum

masa bersalin sehingga tiga hari selepas bersalin. Hasil kajian ini menunjukkan bahawa terdapat penurunan dalam suhu dan peningkatan dalam kelonggaran ligamen sacrosciatic dan kepekatan glukosa darah sebelum bersalin. Namun begitu, kesannya tidak signifikan ($P>0.05$). Kolerasi positif yang tinggi ($r = 0.60$-0.79) telah ditemui antara kepekatan glukosa darah dan hari menghampiri bersalin iaitu tiga hari sebelum bersalin sehingga hari bersalin. Kolerasi positif purata ($r = 0.40 - 0.59$) juga didapati antara kelonggaran ligamen sacrosciatic kanan dengan hari menghampiri bersalin. Ini menunjukkan bahawa kepekatan glukosa darah dan ligamen sacrosciatic berubah apabila menghampiri hari bersalin.

Kata kunci: Bersalin; suhu; ligamen sacrosciatic; glukosa; kambing

ABSTRACT

An abstract of the project paper presented to the Faculty of Veterinary Medicine in partial fulfilment of the course VPD 4999 – Final Year Project

PREDICTION OF PARTURITION IN SAANEN GOATS USING MORPHOMETRY, PHYSIOLOGY AND BIOCHEMICAL PARAMETERS

by

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2021

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In order to predict the time of parturition in does, farmers and producers have previously relied on visual observation. However, these parameters are subjective and do not determine the time of parturition accurately. Thus, this study was carried out to determine the changes of measurable parameters such as temperature, sacrosciatic ligament relaxation and blood glucose concentration and their correlation with the timing of

parturition. Six late gestation does were used in this study. Data for rectal temperature, sacrosciatic ligament relaxation and blood glucose concentration were collected daily from the does starting from 3 days pre-partum until 3 days post-partum. The results showed that there was numerical decrease in the temperature as well as increase in the sacrosciatic ligament relaxation and blood glucose concentration prior to parturition but the results were not significant ($P > 0.05$). A strong positive correlation ($r = 0.60$-0.79) was found between the blood glucose concentration and days approaching parturition which was from 3 days pre-partum to the day of parturition. An average positive correlation ($r = 0.40$-0.59) was also found between the right sacrosciatic ligament relaxation with the day approaching to parturition. This indicates that blood glucose concentration and sacrosciatic ligament changed as the day of parturition approached.

Keywords: Parturition; temperature; sacrosciatic ligament; glucose; goat

CHAPTER 1: INTRODUCTION

1.1 Study Background

Parturition is the series of events that happen at the end of pregnancy when the fetus and its associated membranes are expelled. A physiologically normal parturition occurs without any side effects that may cause harm to the dam or the offspring. However, pathological conditions may arise during parturition that slows or hinders the completion of the normal birthing process and a dystocia is said to occur (Sloss & Duffy, 1980).

Dystocia occurs frequently in ruminants especially in primiparous animals due to the small pelvic canal diameter. Proper supervision of the doe during parturition is important as early intervention in dystocia cases have better outcome for both dam and kids (Ismail, 2017). In order to be present at parturition, the producer needs to know the appropriate time for assistance as well as when the doe will kid. This can be done by estimating the time that parturition is to occur by determining measurable indices of predicting parturition. Physical indicators on cattle such as changes in rectal temperature and changes in progesterone level as well as the animal's external changes such as pelvic ligament relaxation and udder distension can be measured in order to predict the time of parturition. It has been shown that cattle experience relaxation of the sacrosciatic ligaments and reduction in the progesterone concentrations prior to parturition (Streyl et al., 2011). According to Burfeind et al. (2011), rectal temperature in cattle will also decrease before onset of calving. Besides, increase in glucose levels can be observed

during calving as a result of stress (Vannucchi et al., 2015). Normal glucose concentration in goats is between 2.8-4.2 mmol/L (Quandt et al., 2018).

There is currently limited information available on the process and methods of determining parturition time in does. With a determined method, farmers will be able to pay closer attention to their animals and prevent perinatal mortality. Hence, this study will determine the correlation between changes in rectal temperature, sacrosciatic ligament relaxation and blood glucose with the time of parturition in gestating does.

1.2 Justification

Farmers currently depend on visual inspection of changes that are seen in does to estimate the time of parturition e.g., udder enlargement, laxity of the tailhead, restlessness and reduction in appetite. However, these parameters are subjective and do not determine the time of parturition accurately. This study was proposed in order to determine objectively the changes in measurable parameters and their correlation with the timing of parturition. With this information, farmers can accurately predict the time of parturition and be better prepared in terms of management of labour and timing of workers on the farm. Primiparous does can be monitored more closely during the time of parturition as dystocia occurs more frequently in this group of animals. With that, animals can be assisted when necessary thereby decreasing pain and death while farmers will be able to benefit economically in terms of not having to treat injured dams (due to dystocia) or experience profit loss (due to death of neonates).

1.3 Objective

1. To determine the correlation between changes in rectal temperatures, sacrosciatic ligament relaxation and plasma glucose concentration with the time of parturition in goats.

1.4 Hypothesis

H_o: There is no correlation between changes in the rectal temperature, sacrosciatic ligament relaxation and blood glucose concentration of gestating does with the time of parturition.

H_a: There is correlation between changes in the rectal temperature, sacrosciatic ligament relaxation and blood glucose concentration of gestating does with the time of parturition.

CHAPTER 2: LITERATURE REVIEW

2.1 Goat in Malaysia

The meat of domestic goat (*Capra aegagrus hircus*) is referred as goat meat. *Chevon* is known as meat from adults while *Cabrito* is known as meat from young animals. However, "mutton" is commonly used in Malaysia as the term for both goat and lamb meat (Kaur, 2010). In Malaysia, high dependence on ruminant meat importation and insufficiency in local production are the main concerns in food security. The self-sufficiency level (SSL) for mutton was lowest compared to the others such as swine, chicken, and beef which were 15.51%, 12.73%, 11.45%, 13% and 11.41% from the year 2013 to 2017. This fluctuation happened as there was increase in demand and lack of local supply (Abdullah et al., 2020). In 2020, the total number of goats in Malaysia was estimated to be 320,203 and the consumption of mutton was 1.2 kg per capita. The SSL in 2020 for mutton was only 10.72% (Department of Veterinary Services, 2020).

In 1950, dairy goat farming began when imported breeds such as Jamnapari, Saanen and Anglo Nubian were introduced to Malaysia. Besides Saanen, the most common breeds used in the dairy industry are dual purpose breeds. For example, Anglo Nubian, Jamnapari and Boer were also used since 2009. For dairy goat, there is no official recorded data for the production and consumption of goat milk in Malaysia as the majority of production in milk is conquered by cow's milk. Besides, goat milk is often categorised together in the statistical data with cow and buffalo milk (Shahudin et al., 2018).

Goats are considered one of the most fertile animals among the domestic species and there is usually no problems that arise during parturition. In goats, the overall mating and conception rate are considered very high at 96% to 98% (Engum & Lyngset, 1969). According to Robertson et al. (2020), the expected conception rates in goats are approximately 100%. In Australia, the conception rate of the commercial herds can exceed 93%. However, a conception rate of 60% have also been reported. Besides, goats are also considered as prolific breeders with high rates of fecundity. For example, the fecundity rate in Boer is 2.0 kids per doe while the fecundity of Kalahari Red is 1.6 kids per doe.

2.2 Dystocia in goats

The incidence of dystocia in small ruminants is considered low which is less than 5% worldwide. Dystocia occurs when there is delay in the first or second stage of parturition or there is failure of progression to the next stage within 30 minutes. Dystocia in small ruminants can be due to either maternal or fetal factors. Fetal malformations, breech presentation, forelimb flexion and head deviation are the common fetal related factors of dystocia while failure of cervical dilation is a factor most associated with maternal related dystocia (Ismail, 2017). According to Pugh and Baird (2012), fetal posture abnormalities is the most common cause of dystocia. Other causes of dystocia include prolapse of the cervicovagina, inertia of uterus, disproportion of the fetal-maternal size and incomplete dilation of cervix.

2.3 Parturition

In pregnant does, parturition occurs as a series of events. The process is started with the activation of the fetal hypothalamic-pituitary-adrenal axis and is followed by the release of adrenocorticotropic hormone (ACTH) which will then stimulate the fetal adrenal glands to release corticosteroids (Pugh & Baird, 2012). The production of fetal cortisol increases as a result of fetal stress which develops when the supply to the growing fetus by placenta decreases. As the production of fetal cortisol increases, the placental progesterone will be converted to estrogen which then stimulates the prostaglandin F2α (PGF2α) production by the myometrium. PGF2α will cause myometrial contraction which will increase the intrauterine pressure, push the fetus towards the cervix and further dilates the cervix. As the fetus dilates the cervix, oxytocin will be released to induce myometrial contractions (Jackson, 1995).

Similar to other species of animals, the parturition process is divided into three stages. In the first stage of parturition, myometrial contraction is initiated as the progesterone levels decrease and the estrogen levels increase. Does may show signs of abdominal discomfort including lying down, pawing at the bedding as well as frequent urination and defecation. During this period, there will be relaxation of the cervix and contraction of the uterus that allows the placenta and fetus to be pushed toward the cervix, further dilating the cervix. This stage usually lasts from 2 to 12 hours.

The second stage of parturition is initiated when the placenta and fetus are in contact with the vagina and accompanied by simultaneous abdominal

contractions. This stage will last from 1 to 3 hours depending on the number of fetuses present. During this stage, the chorioallantois will rupture, then the amnion will be delivered partially through the vulvar opening and followed by rupture of the amniotic sac and delivery of the kids. The third stage of parturition happens when the placenta is delivered out of the body and usually happens within 1 hour in goats. Retained placenta is considered when the placenta is not expelled by 12 hours (Youngquist & Threlfall, 2007).

2.4 Prediction of parturition in goat

Prediction of parturition and precise kidding monitoring are essential in minimizing the incidence of dystocia in goats. Predicting the time of kidding is crucial for the health of neonates and dams as it helps to prevent injuries to the kids. Physiological indicators such as changes in rectal temperatures and progesterone profiles can be utilised to predict the parturition time. Besides, prediction of parturition can also be made based on individual external signs such pelvic ligaments relaxation, swelling of vulva and udder distension (Streyl et al., 2011). According to Lickliter (1985), behavioural changes such as isolation from the herd, repeated vocalization and restlessness can be observed prior to parturition. Lying down for a few minutes, getting up and walking and followed by lying down again are the typical signs of a doe prior to parturition. Close observation of parturition in the doe is important for timely assistance in order to have satisfactory results for both dam and neonate (Ismail, 2017).

2.4.1 Sacrosciatic ligament

Ligaments are made up of dense regular connective tissue that are in parallel arrangement which provide a considerable strength for the attachment of bones to bones. The non-articular projections and depressions on the bones provide regions for tendon or ligaments attachments (Frandson et al., 2009). Sacrosciatic ligament is made up of connective tissues that form the dorsal part of the pelvic cavity's lateral wall while the ischium and ilium form the ventral part of the lateral wall. The greater and lesser ischiatic foramina is formed from the course of sacrosciatic ligament on ischiatic spine as well as the greater and lesser ischiatic notches of the pelvic of cattle. The cranial gluteal artery and vessels, cranial and caudal gluteal nerves as well as the sciatic nerve will pass through the greater ischiatic foramen while the caudal gluteal artery and vein will pass through the lesser ischiatic foramen (Mansour et al., 2017).

As parturition approaches, sacrosciatic ligaments become progressively relaxed especially in animals such as cows, buffalo, sheep, and goats. Changes in the hormonal milieu including estrogen and relaxin will lead to the sinking of the croup ligaments and muscles as well as the raising of tail head. These changes are most obvious in cows whereby parturition will most likely occur in 24 to 48 hours when there is presence of very relaxed ligaments. However, the relaxation of sacrosciatic ligaments is less significant in animals such as sow, bitch, cat and mare (Purohit, 2010). According to Shah et al. (2006), relaxation of ligaments for more than 5 mm from the measurement of the preceding day was the most useful indication in foreseeing calving within 24 hours. Measurement of sacrosciatic

ligament relaxation is considered as an economical method and can be applied easily in the field.

2.4.2 Temperature

According to Pugh and Baird (2012), the normal rectal temperature in goats is between 38°C to 40°C. Any stress, excitement, increased environmental temperature and humidity or inflammatory disease can result in hyperthermia while old age or malnutrition in animals can lead to hypothermia. There is an association between the steroid hormone concentrations and the temperature of the body prior to parturition. In cattle, the decrease in body temperature before parturition is highly associated with rapid decline in the concentration of progesterone (Nagel et al., 2020). According to Nabenishi and Yamazaki (2017), fluctuations of body temperature in pregnant animals are associated with the change of plasma progesterone concentration that is secreted from corpus luteum during pregnancy. Regression of corpus luteum followed by subsequent decrease in concentration of progesterone will lead to decrease in body temperature. This can be used to predict the time of parturition by measuring the decrease in body temperature. Besides, the decrease in maternal body temperature before giving birth can be the consequence of an increase in the placental blood flow which then increases the fetal temperature to mitigate the loss of heat in neonates (Ricci et al., 2018). Prediction of parturition based on the changes in body temperature is most useful especially in dogs (Nagel et al., 2020). In bitch, the body temperature will drop by 1°C 24 hours before whelping (Purohit, 2010).

2.4.3 Glucose

Glucose is the product of carbohydrate after digestion and it is significant compared to other nutrients as it is the only fuel that can be utilized by the central nervous system. Hence, it is important to maintain a steady supply of glucose in the body for the metabolism of the brain through homeostasis. Glucose is stored in the liver and skeletal muscle as glycogen and can be released from glycogen through glycogenolysis (Klein, 2013). In goats, the normal blood glucose concentration is between 2.8 to 4.2 mmol/L (Quandt et al., 2018).

Stress hyperglycemia is a response that is seen in ill patients. It is an outcome of elevation in the catecholamines, cytokines, cortisol and growth hormone levels as cortisol helps to maintain the equilibrium of glucose in the body. This is to prevent hypoglycemia from happening in animals with prolonged stress or illness. Parturition is known as a stressful event with significant changes can be observed in the plasma catecholamines concentration in both mother and the fetus. The maternal glucocorticoids concentration increases as there is presence of stress going on during parturition. Increase in cortisol level will lead to increase in fetal hepatic gluconeogenesis and minimization of glucose uptake and muscle metabolism. Hence, this will result in elevation of glucose level in the blood (Vannucchi et al., 2015).

2.5 Glucometer

Glucometers are widely used in the assessment of glucose either in management of critical cases or in animal research. In small animal patients,

glucometers are used for rapid assessment of glucose concentration especially in diabetic or pediatric animals and animals that require intensive care. Besides, glucometers are commonly used as they are portable, cheap, small, and easy to be used as well as small quantities of samples are needed (Okorie-Kanu et al., 2018; Quandt et al., 2018). Goats with reproductive diseases can undergo abnormalities in the blood glucose level while newborn kids commonly suffer from neonatal hypoglycemia. Hence, an accurate glucometer is important in monitoring and diagnosing disease in goats either in the clinical settings or in the field setting. However, there are no specific glucometers to be used for large animals. Therefore, there might be a difference in the blood glucose level measured by glucometer as compared to those measured by reference laboratory analyser (Quandt et al., 2018).

2.5.1 Accu-Chek Guide®

Accu-Chek Guide® consists of Accu-Check Guide test strips and a Accu-Check Guide meter that quantitatively measure the glucose in fresh capillary whole blood taken from the forearm, finger, palm and upper arm in order to monitor the glucose control's effectiveness. It is suitable to be used for self – testing but not for diagnosing diabetes mellitus. The Accu-Check Guide test strip should be stored at the temperatures between 4°C to 30°C with relative humidity between 10 % to 90% and used at temperatures between 4°C to 45°C as temperature and humidity outside the required range can damage the test strips and produce inaccurate readings. The test strip needs to be used immediately after

removing it from the container. The reagent composition of test strips consists of stabilizer (2.3%), mediator (6.6%), FAD-GDH enzyme (21.3%), buffer (22.6%) and non-reactive ingredients (47.2%). A sample size of approximately 0.6 µL of blood will be dropped on the yellow edge of the test strip. The blood will then react with the chemicals in the test strips and create electrical current that will be read by the meter. The blood glucose result will appear on the display in less than 4 seconds (Roche Diagnostics GmbH, 2016).

CHAPTER 3: MATERIALS AND METHODS

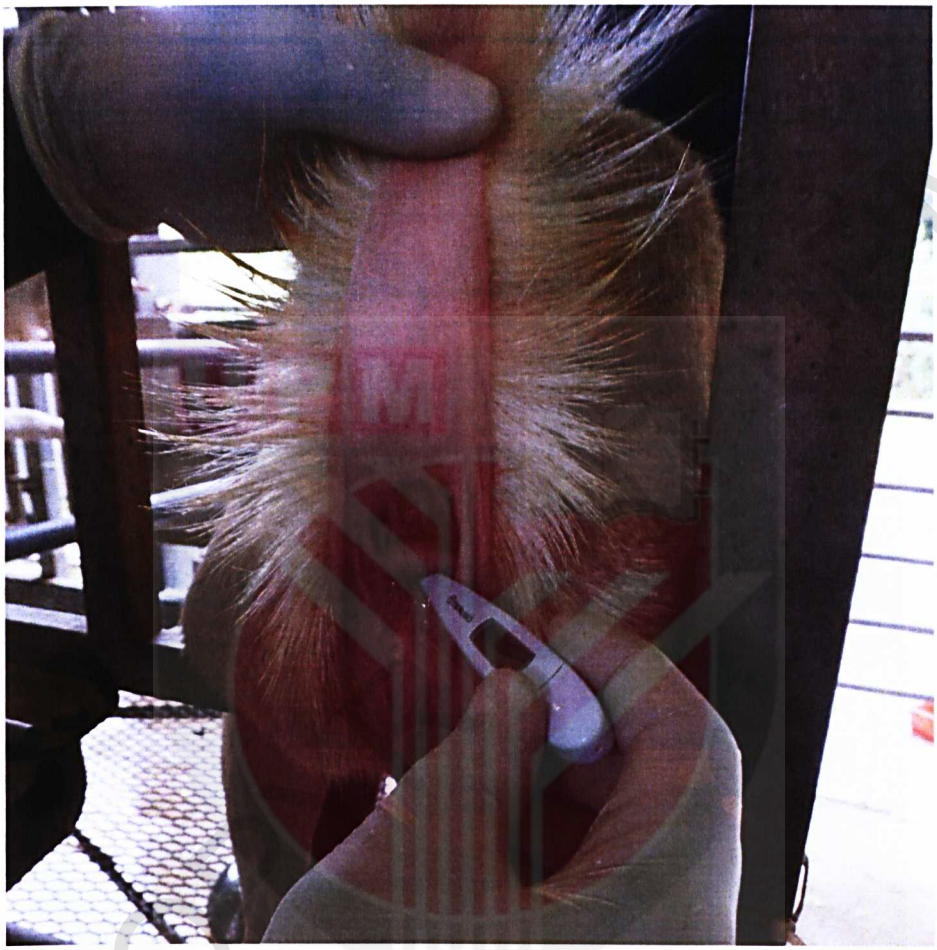
3.1 Animals

This study was approved by the IACUC (International Animal Care and Use Committee) with the reference number: AUP-R075/2019. Six late gestating Saanen does aged between 4 to 8 years old that were expected to kid within 3 days were used in this study. Data was collected from the does from 3 days before parturition until 3 days after parturition between 8 and 10 am daily. The does were kept in individual pens at ITAFoS, UPM and were fed with goat pellets, Napier grass and water *ad libitum*. These animals were previously estrus synchronized and natural mating was done.

3.2 Rectal temperature

Each goat was restrained in standing position and a small amount of KY jelly (Durex®) was used to lubricate the thermometer before inserting into the rectum. Rossmax TG380 digital flexible thermometer was advanced into the rectum and was pushed sidewards so that the bulb of the thermometer touched the rectal mucosa. Once a beeping sound was heard, the thermometer was removed and the result was recorded.

Figure 3.1: Measurement of Rectal Temperature Using Digital Thermometer



3.3 Sacrosciatic ligament relaxation

The hair at the rump of the goats at the area of the sacrum and tuber ischii was clipped. The sacrosciatic ligament relaxation was measured using two rulers that were placed perpendicularly to each other at the region of the ligament. One ruler was placed parallel to the sacrosciatic ligament which was between the sacrum and the tuber ischii while another ruler was placed perpendicularly to the first ruler with the bottom edge touching the ligament and the other edge touching

the front edge of the first ruler. The relaxation was measured in the second ruler from the touching point of ligaments to the touching point of the first ruler (Shah et al., 2006). The measurement of sacrosciatic ligament relaxation was done daily during the last week of gestation.

Figure 3.2: Measurement of sacrosciatic ligament relaxation using two rulers placed perpendicularly to each other

3.4 Blood collection

The goat was restrained in a standing position with the head elevated and turned to one side to expose the jugular vein. The jugular vein was then occluded by applying pressure at the base of the jugular groove to visualize the vein. The insertion area was swabbed with alcohol. With the bevel facing up, a 21G needle

with 5 mL syringe was inserted through the skin and into the vein at approximately 20-30°angle. A total of 5 mL of blood was collected into plain tubes from each goat. The needle was removed once the collection was completed. Pressure applied at the base of the jugular groove was then released and reapplied at the injection site for 30 to 60 seconds to prevent hematoma formation. Blood collection was done daily during the last week of gestation until 3 days post-partum. Within 3 hours of collection, the rest of the blood was spun down at 1500 rpm for 15 minutes and the serum was transferred to cryovial tubes before being stored at -20°C.

Figure 3.3: Blood collection via jugular vein

3.5 Blood glucose evaluation via glucometer

The Accu-chek Guide ® glucometer was used in this study to determine the glucose level in the blood. A minimum of 0.6µL of plasma was dropped on the test strip and the test result appeared on the display in less than 4 seconds. The normal blood glucose level falls between 2.8 to 4.2 mmol/L (Quandt et al., 2018). Immediately after blood was collected, a drop of it was used to determine the blood glucose concentration for the does.

Figure 3.4: Measurement of blood glucose concentration using glucometer

3.6 Statistical analysis

Data collected were arranged into a spreadsheet (Microsoft Excel 365), reviewed for any missing values or errors and analyzed using IBM SPSS Statistic 23 with P values < 0.05 considered to be significant. The measurement of rectal temperature, sacrosciatic ligament relaxation and blood glucose concentration were analyzed using the basic descriptive statistics for their mean, standard deviation and ranges. The correlation between changes in the rectal temperature, sacrosciatic ligament relaxation and blood glucose concentration of the gestating does with the time of parturition were analyzed using Spearman's Rank Order Correlation. Binary logistic regression analysis and ROC curve analysis were also done in this study.

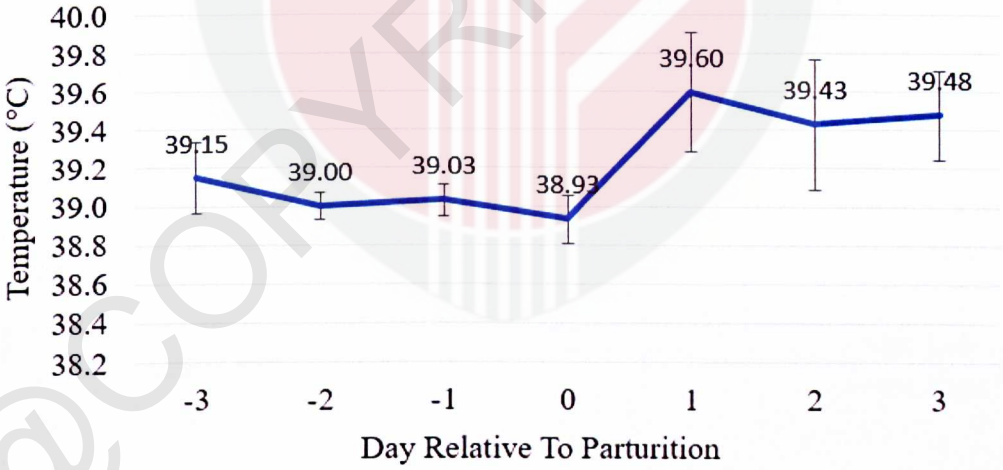
CHAPTER 4: RESULTS

4.1 Descriptive statistics

Table 4.1: Mean ± SEM temperature of 6 Saanen goats on days relative to parturition

Day Relative To Parturition	Temperature (°C)
	Mean ± SEM
-3	39.15 ± 0.18
-2	39.00 ± 0.07
-1	39.03 ± 0.08
0	38.93 ± 0.13
1	39.60 ± 0.31
2	39.43 ± 0.34
3	39.48 ± 0.23

Figure 4.1: Temperature of 6 Saanen goats on days relative to parturition



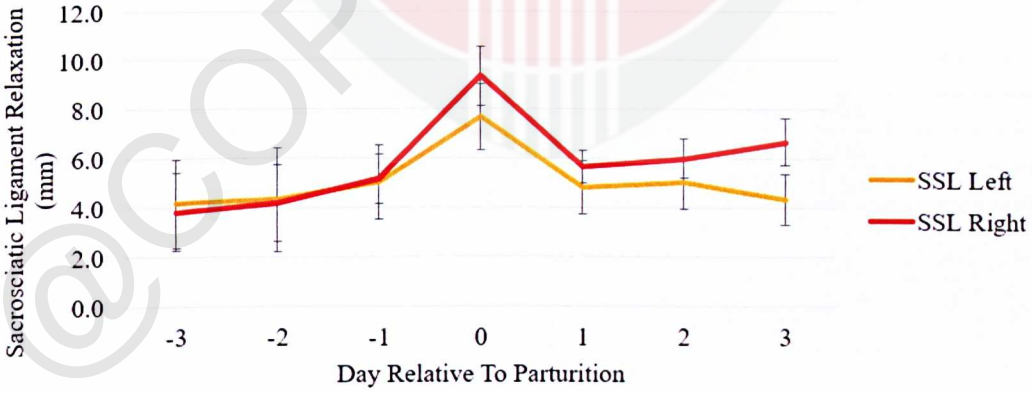
In Figure 4.1, the temperature of goats decreased slowly with a mean of 39.15 ± 0.18 °C on day -3 to 38.93 ± 0.13 °C on the day of parturition (day 0). The temperature then increased sharply to 39.60 ± 0.31 °C on day 1 of parturition and decreased back to

39.48 ± 0.23 °C on day 3 of parturition. However, there was no significant difference (P > 0.05) in the temperature of goats from day -3 to day 3.

Table 4.2: Mean ± SEM of left and right sacrosciatic ligament relaxation of 6 Saanen goats on days relative to parturition

Day Relative To Parturition	Left Sacrosciatic Ligament Relaxation (mm)	Right Sacrosciatic Ligament Relaxation (mm)
	Mean ± SEM	Mean ± SEM
-3	4.17 ± 1.80	3.83 ± 1.60
-2	4.33 ± 2.11	4.17 ± 1.56
-1	5.00 ± 1.51	5.17 ± 1.01
0	7.67 ± 1.33	9.33 ± 1.23
1	4.83 ± 1.08	5.67 ± 0.67
2	5.00 ± 1.03	6.00 ± 0.82
3	4.33 ± 1.02	6.67 ± 0.96

Figure 4.2: Left and right sacrosciatic ligament relaxation of 6 Saanen goats on days relative to parturition



The left sacrosciatic ligament relaxation increased gradually from day -3 to day 0 with the mean of 4.17 ± 1.80 mm to 7.67 ± 1.33 mm. It then decreased from day 1 to day

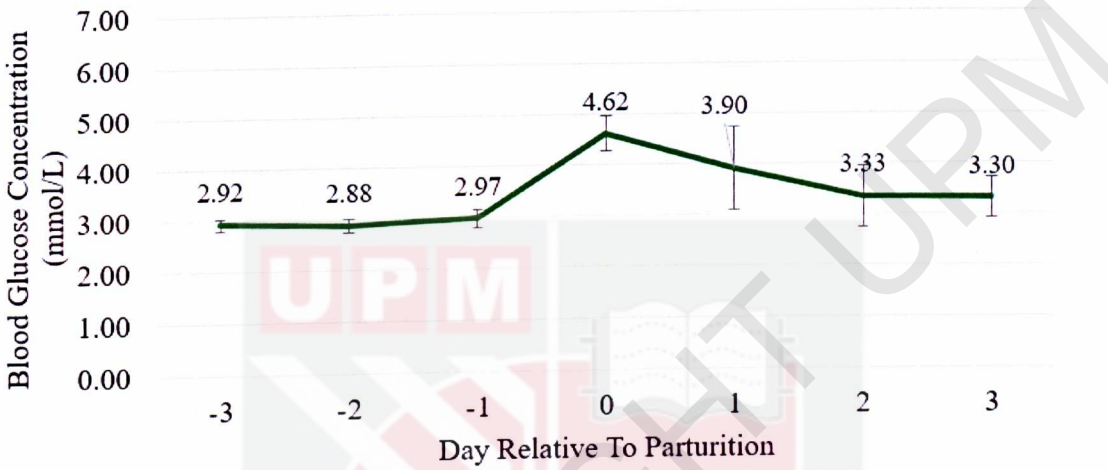
3 with the mean of 4.83 ± 1.08 mm to 4.33 ± 1.02 mm. However, there was no significant difference ($P > 0.05$) in the left sacrosciatic ligament relaxation from day -3 to day 3.

The right sacrosciatic ligament relaxation increased gradually from day -3 to day -1 with the mean of 3.83 ± 1.60 mm to 5.17 ± 1.01 mm. A sharp increase in the sacrosciatic ligament relaxation can be seen on day 0 with the mean of 9.33 ± 1.23 mm and it was followed by a sharp decrease to 5.67 ± 0.67 mm on day 1. It then increased gradually from day 2 to day 3 with the mean of 6.00 ± 0.82 mm to 6.67 ± 0.96 mm. There was a significant difference ($P < 0.05$) in the right sacrosciatic ligament relaxation at day -3 compared to day 0 and day -2 compared to day 0.

Table 4.3: Mean ± SEM of blood glucose concentration of 6 Saanen goats on days relative to parturition

Day Relative To Parturition	Blood Glucose Concentration (mmol/L)
	Mean ± SEM
-3	2.92 ± 0.12
-2	2.88 ± 0.13
-1	2.97 ± 0.18
0	4.62 ± 0.35
1	3.90 ± 0.83
2	3.33 ± 0.60
3	3.30 ± 0.40

Figure 4.3: Blood glucose concentration of 6 Saanen goats on days relative to parturition



In Figure 4.3, the blood glucose concentration of goats was stable from day -3 to day -1 with the mean of 2.92 ± 0.12 mmol/L, 2.88 ± 0.13 mmol/L and 2.97 ± 0.18 mmol/L. An increase of blood glucose concentration can be observed on day 0 with the mean of 4.62 ± 0.35 mmol/L. It was then followed by a gradual decrease of blood glucose concentration from day 1 to day 3 with the mean of 3.90 ± 0.83 mmol/L to 3.30 ± 0.40 mmol/L. However, there was no significant difference in the blood glucose concentration from day -3 to day 0.

4.2 Correlation

Table 4.4: Spearman correlation between days approaching to parturition with temperature, left and right sacrosciatic ligament relaxation, and blood glucose concentration in 6 Saanen goats.

Independent variables	R value	Strength of Relationship	P value[a]
Temperature (°C)	-0.168	Very weak	0.431
Left Sacrosciatic Ligament Relaxation (mm)	0.352	Weak	0.091
Right Sacrosciatic Ligament Relaxation (mm)	0.512	Average	0.011
Blood Glucose Concentration (mmol/L)	0.686	Strong	0.000

[a] Correlation is significant when P value is less than 0.05.
*Dependent variable: Day approaching to parturition

In Table 4.4, there was a very weak negative correlation between the temperature of goats and the day approaching parturition with the R value of – 0.168. There was also a weak positive correlation between the left sacrosciatic ligament relaxation and the day approaching parturition with R value of 0.352. However, these two correlations were not statistically significant ($P > 0.05$).

In contrast, there was a statistically significant positive correlation between right sacrosciatic ligament relaxation and the day approaching parturition with the R value of 0.512. The blood glucose concentration in goats and the day approaching parturition were positively correlated with the R value of 0.686. This correlation was strong and statistically significant ($P > 0.05$).

Table 4.5: Spearman correlation between left and right sacrosciatic ligament relaxation in 6 Saanen goats.

Independent variables	R value	Strength of Relationship	P value[a]
Right Sacrosciatic Ligament Relaxation In Goats (mm)	0.657	Strong	0.000

[a] Correlation is significant when P value is less than 0.05.
*Dependent variable: Left sacrosciatic ligament relaxation in goats.

From Table 4.5, there was a positive correlation between the left and right sacrosciatic ligament relaxation with the R value of 0.657. This correlation is strong and statistically significant ($P < 0.05$).

4.3 Binary logistic regression

Table 4.6: Binary logistic regression analysis of temperature, left and right sacrosciatic ligament relaxation, and blood glucose concentration with the days relative to parturition in 6 Saanen goats

Variables	B	Exp(B)	P value[a]
Temperature (°C)	-111.110	0	0.996
Left Sacrosciatic Ligament Relaxation (mm)	-11.395	0	0.997
Right Sacrosciatic Ligament Relaxation (mm)	11.631	112573.485	0.996
Blood Glucose Concentration (mmol/L)	53.256	1.345E + 23	0.996

In Binary logistic regression, all the parameters were not significant.

4.4 ROC curve

Figure 4.4: ROC curve for temperature of 6 Saanen goats

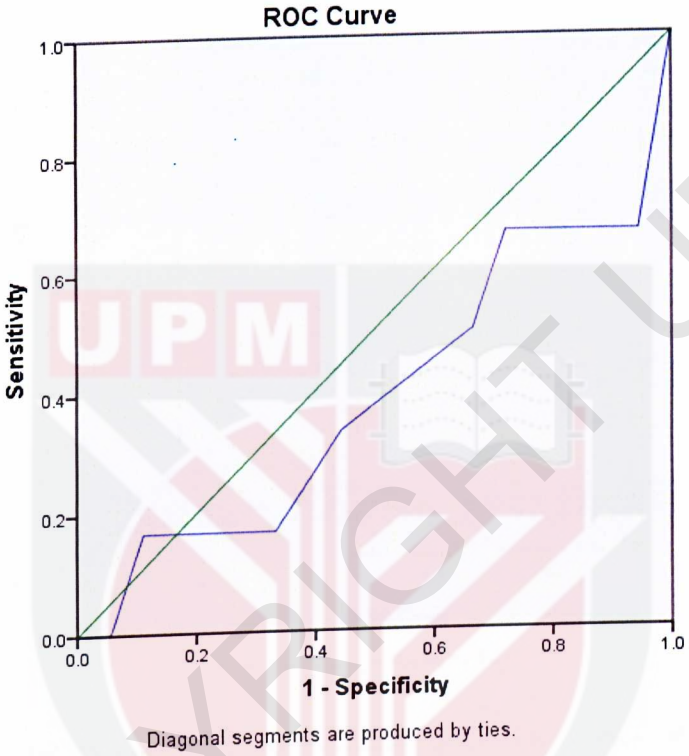


Table 4.7: ROC curve analysis of temperature of 6 Saanen goats

Variable	Optimal cut point	AUC	Sensitivity	1 - Specificity
Temperature (°C)	< 38.85	0.389 (0.106 – 0.671)	0.67	0.72

The optimum cut-point for the prediction of parturition from day -3 to day 0 was temperature lower than 38.85°C (AUC = 0.389), equivalent to P = 0.424. The sensitivity of the test was 67% while the 1- specificity of the test was 72%. However, the ROC curve for temperature was not significant in this study (P > 0.05).

Figure 4.5: ROC curve for left sacrosciatic ligament relaxation of 6 Saanen goats

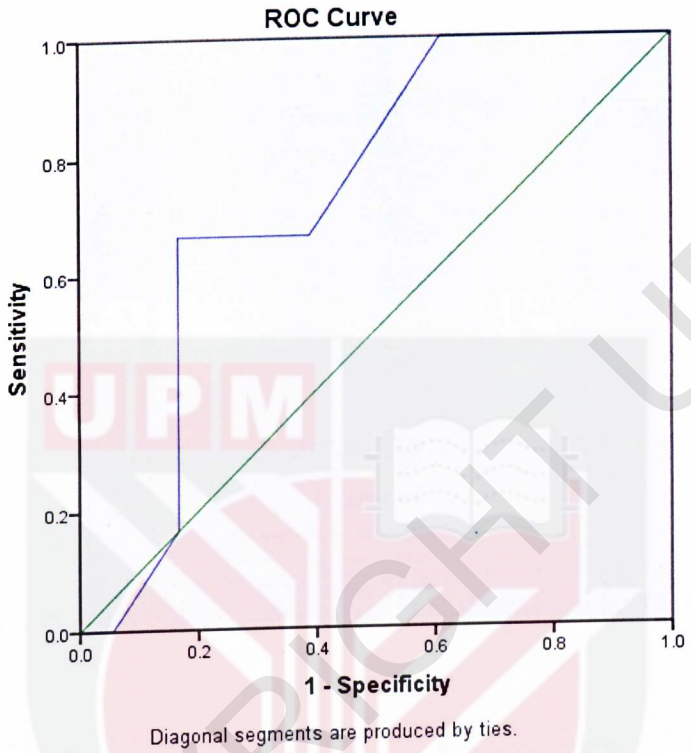


Table 4.8: ROC curve analysis of left sacrosciatic ligament relaxation of 6 Saanen goats

Variable	Optimal cut point	AUC	Sensitivity	1 - Specificity
Left sacrosciatic ligament relaxation (mm)	> 6.0	0.731 (0.552 – 0.941)	0.67	0.17

The optimum cut-point for the prediction of parturition from day -3 to day 0 was left sacrosciatic ligament relaxation more than 6.0 mm (AUC = 0.731), equivalent to P = 0.096. The sensitivity of the test was 67% while the 1- specificity of the test was 17%. However, the ROC curve for left sacrosciatic ligament relaxation was not significant in this study (P > 0.05).

Figure 4.6: ROC curve for right sacrosciatic ligament relaxation of 6 Saanen goats

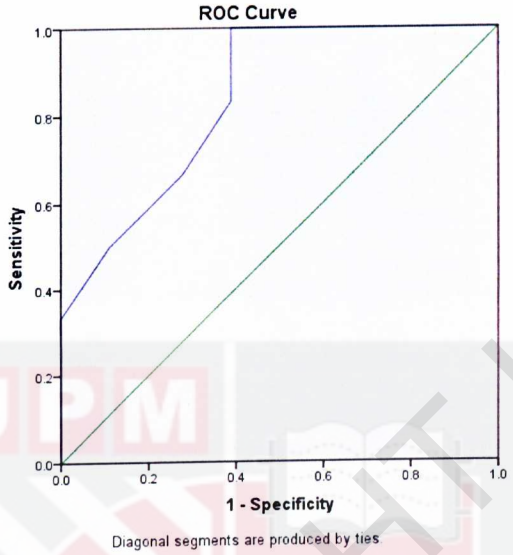


Table 4.9: ROC curve analysis of right sacrosciatic ligament relaxation of 6 Saanen goats

Variable	Optimal cut point	AUC	Sensitivity	1 - Specificity
Right sacrosciatic ligament relaxation (mm)	> 7.5	0.838 (0.669 – 1.000)	0.67	0.28

The optimum cut-point for the prediction of parturition from day -3 to day 0 was right sacrosciatic ligament relaxation more than 7.5 mm (AUC = 0.838), equivalent to P = 0.015. The sensitivity of the test was 67% while the 1- specificity of the test was 28%. With AUC of 0.954, this indicates that relaxation of right sacrosciatic ligament is a good test to predict parturition time in goats.

Figure 4.7: ROC curve for blood glucose concentration of 6 Saanen goats

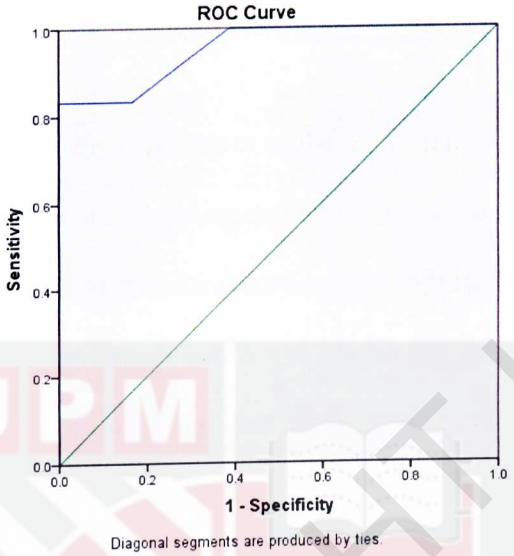


Table 4.10: ROC curve analysis of blood glucose concentration of 6 Saanen goats

Variable	Optimal cut point	AUC	Sensitivity	1 - Specificity
Blood glucose concentration (mmol/L)	> 3.45	0.954 (0.857 – 1.000)	0.83	0.06

The optimum cut-point for the prediction of parturition from day -3 to day 0 was blood glucose concentration higher than 3.45 mmol/L (AUC = 0.954), equivalent to P = 0.001. The sensitivity of the test was 83% while the 1 - specificity of the test was 6%. With AUC of 0.954, this indicates that blood glucose concentration is an excellent test to predict parturition time in goats.

CHAPTER 5: DISCUSSION

5.1 Temperature

A decreasing trend in the temperature of the goats could be observed from day -3 to the day of parturition (day 0). The temperature of goats reached the lowest point at 38.93°C on the day of parturition. Similar results can be seen in a study done by Burfeind et al. (2011) whereby the temperature was lower on the day of parturition compared to previous days. Ewbank (1969) reported that there was a consistent decrease in the temperature over the 9 days before parturition. However, it was shown that animals that exhibited external signs of parturition with the rectal temperature above 38.8°C were unlikely to give birth within 12 hours. Due to the variation of temperature in individual goats, it was impractical to choose a particular temperature as prediction for the onset of parturition in goats. Aoki et al. (2005) also stated that temperature can be affected by differences in individual animals and the temperature of the environment. Hence, parturition cannot be estimated through a single examination (Streyl et al., 2011). There was no statistically significant difference for temperature in this study.

In this study, there was a very weak negative correlation between the temperature of goats and the day of parturition. This indicates that the temperature decreased as the day approached parturition. However, this correlation was not significant which indicates that measuring the changes of temperature was not very useful in predicting parturition. This might be due to the variation in the rectal temperature which was influenced by the weather and body condition of the goats (Winfield & Makin, 1975).

5.2 Sacrosciatic Ligament Relaxation

An increasing trend in both left and right sacrosciatic ligament relaxation can be observed from day -3 to day 0. The sacrosciatic ligaments relaxation for both left and right sides peaked on the day of parturition at 7.67 mm and 9.33mm respectively. This is supported by the study done by Dufty (1971) which showed that there was evidence of slight relaxation of sacrosciatic ligament few days before parturition. Shah et al. (2006) also reported that there was gradual increase in the ligament relaxation as the gestation progressed. However, only the right sacrosciatic ligament relaxation showed statistical significance for day -3 with day 0 and day -2 with day 0.

In this study, there was a weak positive correlation between the left sacrosciatic ligament relaxation and day approaching parturition but this correlation was not significant. In contrast, there was a moderate significant positive correlation between the right sacrosciatic ligament relaxation and the day approaching parturition. This result was similar with the findings of Shah et al. (2006) whereby the measurement of sacrosciatic ligament relaxation increased as it approached parturition and was highest at the time of parturition. In this study, goats with relaxation of right sacrosciatic ligament that was more than 7.5 mm, 67% of them that are expected to labour will give birth within 24 hours. However, there were also 28% of the goats that are not expected to give birth will be falsely classified as going to give birth. With the area under curve of 0.838, right sacrosciatic ligament relaxation is a good test to be used to predict the parturition time in goats. A study reported by Berglund et al. (1987) stated that pelvic ligament relaxation together with udder distension were the most reliable prediction for parturition which would take place within 12 hours.

5.3 Glucose

An increasing trend in the blood glucose concentration could be observed from day -3 to day 0. The glucose concentration was highest on the day of parturition with an average of 4.62 mmol/L. Magistrelli and Rosi (2014) reported that the plasma glucose level increased in goats at parturition. This was due to the release of cortisol at the terminal stage of parturition which then led to increase in the blood glucose concentration. This was also supported by findings of Vannucchi et al. (2015) which showed an increase in the maternal glucose concentration over the time of parturition. However, in this study, there was no significant difference between the days relative to parturition.

In this study, there was a strong positive correlation between blood glucose concentration and days approaching parturition. This was agreed by the study of Mahmoud and Azab (2014) whereby an increase in glucose level was observed prior to parturition as a result of increase in the cortisol level. Besides, in this study, goats with blood glucose concentration of more than 3.45 mmol/L, 83% of the goats that are expected to labour will give birth within 24 hours. Only 6% of the goats that are not expected to give birth will be incorrectly classified as going to give birth. With area under curve of 0.954, blood glucose concentration in goats is an excellent test to predict parturition. This was supported by Hiew et al. (2020) whereby measuring the glucose concentration is an accurate way to predict parturition.

CHAPTER 6: CONCLUSION

In conclusion, there was a numerical decrease in the temperature and increase in both sacrosciatic ligament relaxation and blood glucose concentration in the days before parturition. However, there was no statistically significant difference between these parameters with the days relative to parturition. The right sacrosciatic ligament relaxation had a moderate correlation with the day approaching parturition while glucose was strongly correlated with the day of parturition. Hence, sacrosciatic ligament relaxation and blood glucose concentration could be used as indicators for parturition.

CHAPTER 7: RECOMMENDATION

When similar studies are done in the future, it is recommended to collect data on different breeds of goats in order to achieve a better and holistic picture for the changes of temperature, sacrosciatic ligament relaxation and blood glucose concentration prior to parturition. Larger sample sizes are also recommended when collecting data in order to obtain more valid results.

Similar studies can also be done to determine the correlation between the changes of hormones such as progesterone, estradiol and cortisol with the time of parturition in goats in order to predict the time of parturition in goats.

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