UNIVERSITI PUTRA MALAYSIA

DETERMINATION OF THE RELATIONSHIP BETWEEN ULTRASONOGRAPHIC MEASUREMENTS OF LONGISSIMUS DORSI, BACKFAT AND BODY WALL THICKNESS WITH BODY WEIGHT AND TESTICULAR MORPHOMETRY IN BREEDING BUCKS

BOEY JIN WERN

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CERTIFICATION

It is hereby certified that we have read this project paper entitled "Determination of the Relationship Between Ultrasonographic Measurements of Longissimus Dorsi, Backfat and Body Wall Thickness with Body Weight and Testicular Morphometry in Breeding Bucks", by Boey Jin Wern and in our opinion it is satisfactory in terms of scope, quality, and presentation as partial fulfillment of the requirement for the course VPD 4999 – Project

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DEDICATIONS

This write-up is dedicated to:

My family,

Father

Mother

Brothers

Friends

Ee Leng

All my lecturers and faculty staff who have committed themselves towards the noble cause of education

And all the animals that were involved in this study

ACKNOWLEDGEMENTS

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Last but not least, my most heartfelt gratitude to my family: my father, mother, brothers for their boundless love and support throughout my studies. Not forgetting as well, my significant other, Ee Leng.

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ABSTRAK

Abstrak daripada kertas projek yang dikemukakan kepada Fakulti Perubatan Veterinar, Universiti Putra Malaysia untuk memenuhi sebahagian daripada keperluan VPD4999 – Projek Tahun Akhir.

HUBUNGKAIT ANTARA UKURAN KETEBALAN LONGISIMUS DORSI, LEMAK BELAKANG DAN DINDING BADAN SECARA ULTRASONOGRAFI DENGAN BERAT BADAN DAN MORFOMETRI TESTIS KAMBING JANTAN BAKA

Oleh

Boey Jin Wern

2016

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Penyelia Bersama: Prof. Madya Dr. Rosnina Hj Yusoff

Hubungan antara ukuran ultrasonografi ketebalan otot longissimus dorsi, lemak belakang dan dinding badan berbanding berat badan dan morfometri testis telah dikaji di dalam 16 ekor kambing jantan baka yang terdiri daripada baka Boer, baka daging kacukan dan baka tenusu kacukan. Setiap haiwan berumur lebih daripada 2 tahun.. Ukuran ultrasound untuk ketebalan lemak dan otot telah diambil di antara vertebra toraks ke-12

dan ke-13, di antara vertebra lumbar ke-3 dan ke-4 dan di antara tulang rusuk ke-12 dan ke-13 12.7 cm dari tulang belakang untuk mengukur ketebalan dinding badan. Angkup *Vernier* telah digunakan untuk mengukur kepanjangan (L, cm), kelebaran (W, cm) dan ketinggian (H, cm) testis. Ukurlilit skrotum telah diukur dengan menggunakan pita plastic yang kenyal. Kepejalan testis ditentukan melalui palpasi. Image J (versi 1.49) digunakan untuk mengukur imej ultrasound dengan tepat. Isipadu testis telah dikira menggunakan formula: *Isipadu = 0.5233 x L x W x H*. Dari ini, keluaran sperma harian (DSO; 10^9 / hari) dapat dianggarkan dengana formula *DSO = (0.024 x isipadu testis) - 1.26*, di mana jumlah isipadu testis terdiri daripada jumlah isipadu testis kiri dan kanan. Korelasi Pearson (SPSS 23) menunjukkan bahawa ketebalan lemak di bahagian *thoracic* berkait rapat dengan isipadu testis kanan (0.497, P = 0.05). Ketebalan lemak toraks juga berkait rapat dengan panjang testis kanan (P = 0.031). Berdasarkan analisis keseluruhan, berat badan, ketebalan otot dan lemak badan tidak mempengaruhi morfometri testis. Oleh itu, ukuran ini hanya boleh digunakan untuk menilai kualiti karkas dan bukan kesuburan haiwan. Hasil kajian ini juga menunjukkan bahawa berat badan adalah berkait rapat dengan ukurlilit toraks (0.824, P < 0.05) serta ketebalan otot longissimus dorsi kiri (0.722, P = 0.02) dan kanan (0.543, P = 0.03) di bahagian toraks.

Kata Kunci: ultrasound, longissimus dorsi, ketebalan lemak belakang, ketebalan dinding badan, morfometri testis dan ukurlilit skrotum

ABSTRACT

An abstract of the project paper presented to the Faculty of Veterinary Medicine, Universiti Putra Malaysia in partial fulfilment of the course VPD4999 – Final Year Project.

DETERMINATION OF THE RELATIONSHIP BETWEEN ULTRASONOGRAPHIC MEASUREMENTS OF LONGISSIMUS DORSI, BACKFAT AND BODY WALL THICKNESS WITH BODY WEIGHT AND TESTICULAR MORPHOMETRY IN BREEDING BUCKS

By

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2016

Supervisor: Dr. Mark Hiew Wen Han

Co-supervisor: Assoc. Prof. Dr. Rosnina Hj Yusoff

The relationship between ultrasonographic measurements of the longissimus dorsi muscle, backfat and body wall thickness with body weight and testicular morphometry was studied in 16 breeding bucks consisting of Boer as well as crossbreds for meat and dairy purposes. All animals were at least 2-years-old. Ultrasound measurements were taken for fat and muscle depths between the 12^{th} and 13^{th} thoracic vertebrae, 3^{rd} and 4^{th}

lumbar vertebrae and between 12th and 13th ribs 12.7 cm distal to the dorsal vertebral processes to measure body wall thickness. Vernier caliper was used to measure testicular length (L, cm), width (W, cm) and height (H, cm). Scrotal circumference was measured with a flexible plastic tape. The firmness of the testicles was determined by palpation. Image J (version 1.49) was used to accurately measure the ultrasound images. Testicular volume was calculated using the formula: $Volume = 0.5233 \times L \times W \times H$ while the daily sperm output (10^9/day), $DSO = (0.024 \times \text{testicular volume}) - 1.26$; in which the total testicular volume represents the sum of the right and left testicular volume. Pearson's correlation (SPSS 23) showed that the fat depth of left thoracic area was correlated with the right testicular volume (0.497, $P = 0.05$). Meanwhile, the fat depth at the right thoracic area was correlated with the right testicular length ($P = 0.031$). Overall, bodyweight, muscle and fat depths do not have a correlation with testicular morphometry. Therefore, these measurements can only be used to evaluate carcass traits and not fertility. Additionally, body weight was correlated with thoracic circumference (0.824, $P < 0.05$) as well as left (0.722, $P = 0.02$) and right (0.543, $P = 0.03$) longissimus dorsi muscle depth at the area between the 12th and 13th thoracic vertebrae.

Keywords: ultrasound, longissimus dorsi, backfat, body wall thickness, testicular morphometry, scrotal circumference.

1.0 Introduction

Goats play a significant role in the economy and nutrition as well as contribute to the livelihood of rural and urban dwellers (Oluwatomi, 2010) in most developing countries. They also serve as a source of protein and household income for small scale farmers (Peacock *et al*., 2005). Goat meat refers to the meat of the domestic goat (*Capra aegagrus hircus*) and is often called "chevon" when it is from animals of five to eighteen months of age and "cabrito" when it is from young animals. In Malaysia, the word "mutton" is often used to describe both goat and sheep meat, although technically the term refers only to sheep meat. As such, statistics on goat and sheep meat are often grouped together under the heading of mutton (Kaur, 2010). The self-sufficiency level of mutton in Malaysia was only 10.58% in 2010 (Department of Veterinary Service, 2013) and as such there is a huge potential for growth in the small ruminant industry.

The establishment of a good breeding program in farms is important to ensure sustainable production. One of the most important criteria of a good breeding program is the selection of breeding bucks with adequate and desired carcass traits and this can be achieved by using real-time ultrasound. Ultrasonographic measurements of the longissimus dorsi muscle and subcutaneous fat thickness have been used in cattle as a selection criteria to estimate breeding values (Yokoo, 2008). Ultrasound has also been used for years to measure fat and muscle depths in the swine and cattle industry for the purpose of genetic selection programs to improve carcass quality (Moeller, 2002; Williams, 2002).

Currently, no research has been done to study the relationship between ultrasonographic measurements of longissimus dorsi, backfat and body wall thickness with body weight and testicular morphometry in breeding bucks in Malaysia. Hence, the objective of this study was to determine the correlation between measurements of longissimus dorsi, backfat and body wall thickness with body weight and testicular morphometry. It was hypothesized that there is an association between the measurements of muscle and fat thickness with body weight and testicular morphometry in bucks.

2.0 Literature Review

2.1 History of Goats

Goats were one of the earliest animals domesticated by humans (Stamper, 2010). The importance of goats have always been a priority to prehistorical men as they provide meat, fiber, clothing, leather, shelter, tools and milk, which persists until today (Stamper, 2010). Goats maintained their relevancy for humans as goats are relied on for cheese and other diary products, while the remaining older bucks are slaughtered for their meat (Stamper, 2010). Over time, dual-purpose goat breeds were developed to offer sufficient amounts of milk and meat (Stamper, 2010). Goats, due to their habits of browsing, are usually used to keep lands clear of unwanted bush and weeds (Stamper, 2010). Niche markets for goat dairy products exists as they are utilized to make different types of cheese (Stamper, 2010). Worldwide, more people drink and consume dairy products from goats than from cattle (Belanger, 1974). In Malaysia, the self-sufficiency rate for goat meat is still low, therefore there is a big room for improvement of the goat industry in the country. The self-sufficiency level of mutton in Malaysia was only 10.58% in 2010 (Department of Veterinary Service, 2013).

2.2 Body Weight and Thoracic Circumference

It is important to know the live bodyweight because it is a useful parameter for feeding, health and breeding purposes (Slippers *et al.*, 2000). The proper way to measure live body weight is by using weighing scales, but it is often hard and not practical to use such methods in the farm and village settings due to absence of scales and records

(Mahmud, 2014; Abegaz and Awgichew, 2009). Many farmers rely on body characteristics to estimate body weights (Alade *et al*., 2008) because low income farmers cannot afford standard weighing scales (Mahieu, 2011). There is a significant correlation between body weight and thoracic circumference because of the muscles and bones in the thoracic area (Bello, 2012). Thoracic circumference is defined as the circumferential measurement around the chest caudal to the front legs and withers, it is also known as heart girth (Mahmud, 2014). Therefore, thoracic circumference is one of the many ways farmers use to estimate the body weight of the animal.

2.3 Fertility in Bucks

Breeding Soundness Examination (BSE) is a vital tool to assess the ability of bucks to mate and inseminate the female as well as to detect any reproductive tract abnormalities that can affect the buck's reproductive performance (Pezzanite, n.d.). In order to do that, one should palpate the penis, prepuce, sheath, testicles, and epididymis, and measure the scrotal circumference of the animal (Pezzanite, n.d.) which is strongly related to the semen production capacity of the buck (Pezzanite, n.d.). Bucks with larger scrotal circumference produces female progenies that can reach puberty early (Pezzanite, n.d.). To determine whether the animal is good for breeding purpose, a reference chart from Purdue University (Table 1) can be used as a guideline.

2.4 Testicular Morphometry

Class	Scrotal Circumference (<14 months)	Scrotal Circumference (>14 months)	Motility	Morphology	Debris
Excellent	-	>25 cm	> 50 %	> 90 %	No white blood cells
Satisfactory	-	-	> 30 %	> 70 %	No white blood cells
Questionable	-	-	< 30 %	< 70 %	May have white blood cells

Table 1: Classification of bucks according to breeding parameters

Scrotal circumference has shown significant correlation with scrotal length and testicular weight in indigenous goat breeds of Nigeria (Raji *et al*., 2008) as well as having larger testes (Alade *et al*., 2006). Additionally, semen quality, scrotal circumference and testicular biometry were highly correlated with each other in Bengal goats (Kabiraj, 2011). Testicular length is measured in a dorsal-ventral direction, excluding the epididymal tail (Andrade, 2014) while testicular width is measured from the middle portion of each testis in the lateral-medial direction (Andrade, 2014).

Testicular volume is calculated using the formula: Volume = 0.5233 x L x W x H (Love, 1991; Pukazhenthi *et al.* 2011) while the daily sperm output (10^9/day), DSO = (0.024 x testicular volume) – 1.26; in which the total testicular volume represents the sum of the right and left testicular volume (Love *et al.*, 1991). The daily sperm output per testis and per gram of testis in goats is approximately 30 million and 2.8 billion respectively (Leal, 2004).

2.5 Ultrasound

Ultrasound is known as sound waves with frequency above the upper limit of human hearing which is an estimated 20,000 cycles per second (20 kHz) (Nyland, 2002). Diagnostic tests often utilize sound frequencies within the 2-10MHz range (Nyland, 2002). An ultrasound transducer, or scan head, may give out single or multi frequency sound waves (Nyland, 2002). Frequency is understood as the amount of times a wave is recycled per second (Nyland, 2002). While wavelength is known as the length for which a wave travels within a cycle (Nyland, 2002). The relationship between frequency, velocity and wavelength can be understood from the equation: Velocity (m/sec) =Frequency (cycles/sec) x wavelength (m) (Nyland, 2002).

For which the frequency referred to here is directly related to the depth in which sound reaches into soft tissues (Nyland, 2002). The unique characteristics of the special piezoelectric crystals within the scan head have a major influence the frequency emitted by a transducer, and the crystal's frequency is inherent and it is unchangeable with the controls of the scanner (Nyland, 2002). Besides that, the ultrasound imaging is dependent upon the pulse-echo-principle, meaning that the transducer produces sound in pluses instead of in a constant form (Nyland, 2002). Then, with the reverbing echoes with each pulse returning from the tissues back to the transducer, an image will be created (Nyland, 2002). When the special piezoelectric crystal within the scan head is vibrated and swiftly dampened, a sound pulse will be given out by the transducer (Nyland, 2002). The voltage to pulse the crystal is maintained by the power control, which turns to regulate the sound output level of the transducer (Nyland, 2002).

2.6 Veterinary Usage of Ultrasound

In the veterinary field, real-time ultrasonography has been used widely for pregnancy diagnosis and to diagnose various reproductive disorders in bovines because it is rapid, safe, accurate and practical (Ingawale, 2012). Other than that, ultrasound has been used widely to evaluate and select for carcass traits in the beef industry (Herring *et al*., 1994b). Historically, ultrasound has been used to collect measurement data on yearling bulls in test stations (McGrath, n.d.). However, there is concern that ultrasound may not detect phenotypic variation of fat depth when fat deposition is limited by nutritional management (Doeschl-Wilson, 1992).

Based on a study by Bergen (1997), ultrasonographic backfat and ribeye area measurements can be used to predict the lean meat yield in yearling bulls. In swine and cattle, ultrasound fat and muscle depths have been used for several years in genetic selection programs for improving carcass quality (Moeller, 2002; Williams, 2002). Based on a study in New Hampton, Iowa, real-time ultrasound cross-sectional images of the loin muscle are highly correlated with carcass loin muscle area in swine (Ragland *et al*., n.d.).

Real-time ultrasonography is a noninvasive technique that has been used to predict carcass composition and quality. It avoids damage of the product which consequently reduces carcass price (Teixeira *et al*., 2008). Ultrasound can be used to accurately predict longissimus muscle area, longissimus muscle depth and backfat thickness (Leeds *et al*., 2008).

2.7 Longissimus Dorsi

Longissimus is described as “a muscle that originates from the iliac crest, and the spinous and other processes of the lumbar and thoracic vertebrae, innervates the dorsal branches of the spinal nerves and inserts at the transverse processes of the thoracic and cervical vertebrae, and the temporal bone” (Saunders Comprehensive Veterinary Dictionary, 4th Edition) while *Dorsi* is defined as “of, to, or on the back” (Saunders Comprehensive Veterinary Dictionary, 4th Edition).

2.8 Backfat Thickness

Backfat thickness is the measurement of the subcutaneous fat layer between the skin and the deep fascia, above the longissimus dorsi and gluteal muscles (Hussein, 2013). Ultrasonography can be used to measure fat layer and to assess the animal’s energy status and is commonly used in cows in conjunction with BCS (Hussein, 2013).

2.9 Body Wall Thickness

Body wall thickness has been used as a measurement for yield grading purpose by the United States Department of Agriculture (USDA). Body wall thickness is measured 5 inches (12.7 cm) laterally from the middle of the backbone between the 12th and 13th ribs (USDA, 1992). Nathan (2010) showed that body wall thickness is highly correlated with body weight in Boer cross goats in Columbia.

2.10 Correlations between Body Measurements

Many studies have shown that there are correlations between different parts of body measurements in animals like buffaloes (Luz *et al*., 2012), goats (Khan *et al*., 2006) and dairy bulls (Andersson *et al.*, 1992). The measurements of various body conformations prove are major players in forming the quantitative characteristics of meat and they also aid in suitable selection criteria development (Sharaby and Suleiman, 1987; Islam *et al*., 1991). Body measurements have been used to predict body weight in sheep breeds in Pakistan (Sowande and Sobola, 2008 (West African dwarf sheep); Cam *et al*., 2010 (Karayaka sheep); Hassan, 2011 (Lohi sheep); Younas *et al*., 2013 (Hissardale sheep)).

Based on a study conducted on subtropical goat kids in Egypt, both chest circumference and body length are highly correlated with the body weight of kids, while the measurements of body weight, body length and chest circumference are highly correlated with longissimus muscle area (Abdel-Mageed, 2013). There is a significant correlation between height at withers, chest circumference and body length with body weight in various goat and sheep species (Khan *et al*., 2006; Mukherjee *et al*., 1981; Singh *et al*., 2004; Iqbal *et al*., 2014).

3.0 Materials and Methods

3.1 Animals

A total of 16 male breeding bucks from two farms located in Selangor using the convenience sampling method were enrolled into this study. Ten of the bucks were from Taman Pertanian Universiti, Universiti Putra Malaysia, Serdang and the other 6 were from Hikmah Cemerlang farm, Sepang. All 16 bucks were reared in a semi-intensive system and were at least 2-years-old. They mainly consisted of Boer, meat crosses and dairy crosses. There was total of 6 Boers, meat crosses (2 Katjang, 1 Jamnapari, 2 Feral goats, 1 Katjang-Jamnapari cross, 1 Feral-Jamnapari cross) and dairy crosses (1 Saanen, 1 Saanen-Jamnapari cross, 1 Anglo Nubian). Patient signalment, BCS, basic physical examination parameters to evaluate health (temperature, heart rate and respiratory rate), ultrasound measurements and testicular morphometry for each study subject was recorded in individual data sheets. This study was approved by the Institutional Animal Care and Use Committee (IACUC), with the reference number: UPM/IACUC/FYP.2015/FPV.023.

3.2 Longissimus Dorsi Muscle, Backfat and Body Wall Thickness Measurement

Body weight of the animals was taken before the ultrasound imaging using a hanging scale (Salter, model 235). The thoracic circumference of the animal was measured at the vertical plane of the animal's body immediately caudal to the scapula (Wittek *et al*., 2007). Ultrasound measurements were taken by the same operator for every animal using a real-time ultrasound device (SonoScape, Model A6V) with a 70 mm, 5-7 MHz linear probe. Bucks were restrained and were measured for the ultrasound measurements a standing position (Thériault *et al*., 2009). Before each ultrasound session, the different scanning sites were identified and marked with a marker pen by palpating the vertebrae from T12 to L3. The region was clipped (Wahl Super Taper®) and shaved to remove the animal's hair for better surface contact of the ultrasound probe. For every scanning site, ultrasound gel was used as a coupling agent between the probe and skin to reduce artifacts.

Ultrasound measurements were taken on the left and right side of the animal at 3 different sites: fat and longissimus muscle depths between the 12th and 13th ribs perpendicular to the body midline *(Thoracic region)* (Figure 1); fat and longissimus muscle depths between the 3rd and 4th lumbar vertebrae perpendicular to the body midline *(Lumbar region)* (Figure 1); and fat and body wall thickness between the 12th and 13th ribs, 5 inches or 12.7 cm perpendicular to the body midline *(Body wall thickness)* (Figure 1) (Pálsson, 1939). Skin depth was included in all the ultrasound fat measurements because this tissue is not easily distinguishable from the fat layer (Thériault *et al*., 2009) and it is a thin layer (2.5 to 3.0 mm) and shows little variation between animals (Gooden *et al*., 1980; Cameron and Bracken, 1992).

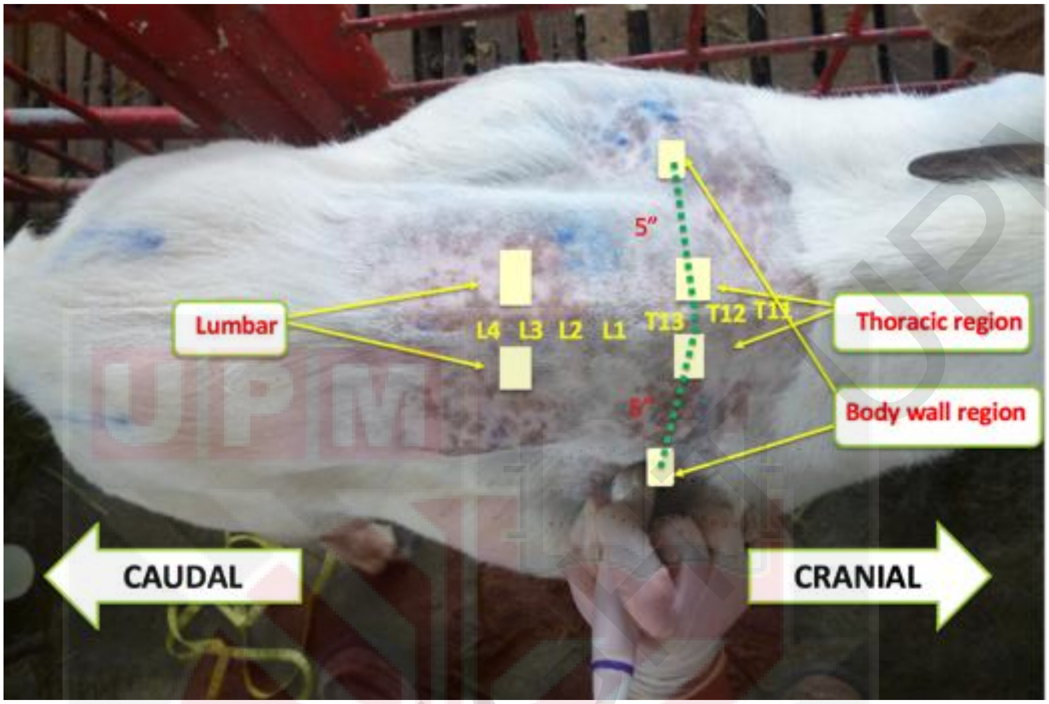

Figure 1: Ultrasonography scanning sites

3.3 Testicular Morphometry Measurement

Measurements of scrotal circumference (cm), testicular length (cm), testicular width (cm), testicular height (cm) and testicular firmness were obtained from the 16 bucks. Scrotal circumference (cm) was obtained with a flexible plastic tape and it was measured at the largest diameter of the testicles and scrotum with the testicles pushed down firmly into the scrotum (Raji *et al*., 2008). Vernier caliper was used to measure testicular length, width and height. Testicular length was measured at the distance between the base and the apex of the testicle, excluding the head and tail of the epididymis (Wahid *et al*., 1991). Testicular width was measured at the distance between the lateral and medial aspects of each testis while testicular height was measured at the distance between caudal and cranial aspects of each testis. The firmness of the testes was determined via palpation. Testicular volume (TV) for each testis was calculated by using the formula: TV = 0.5233 x L x W x H, where L is the testicular length, W is the testicular width and H is the testicular height (Love, 1992; Pukazhenthi *et al*. 2011). Daily Sperm Output (DSO; 10^9/day) for each testis was calculated by using the formula: DSO = (0.024 x testicular volume) – 1.26 (Love *et al*., 1991).

ImageJ 1.49 was used to obtain the measurements from of the previously saved ultrasound images. To measure longissimus dorsi muscle depth, the maximal height between transverse processes was measured (Thériault, 2009). And for backfat thickness, it is the layer over the longissimus dorsi muscle (Thériault, 2009). Backfat appears to be more hyperechoic than muscle.

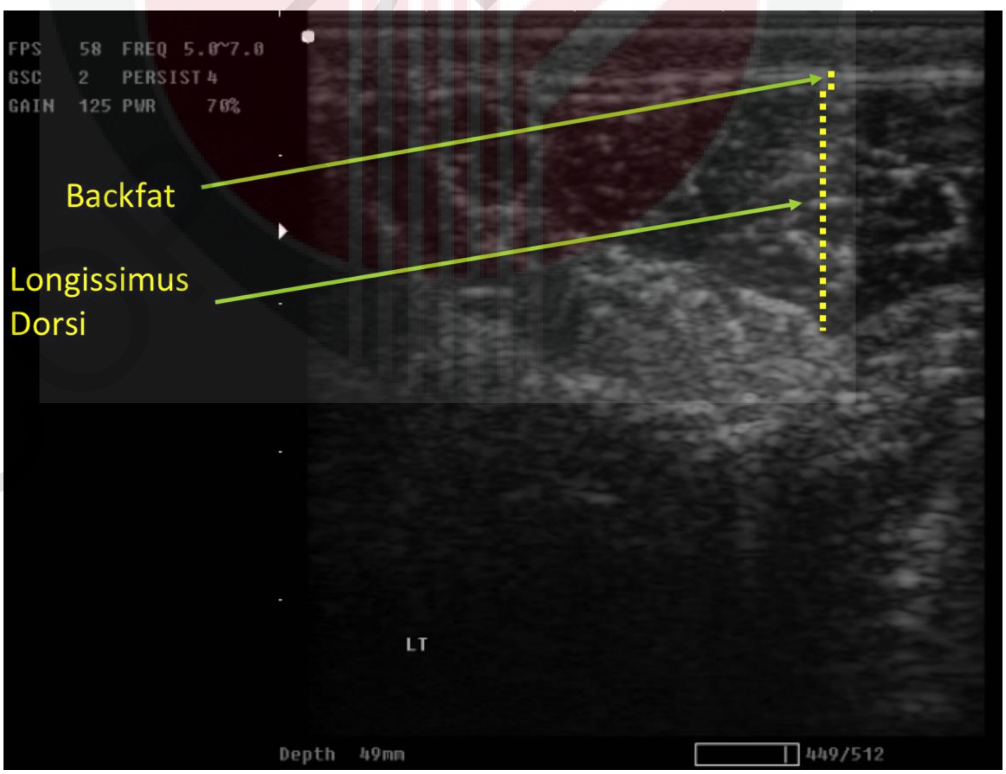

Figure 2: Ultrasound image of the left thoracic region

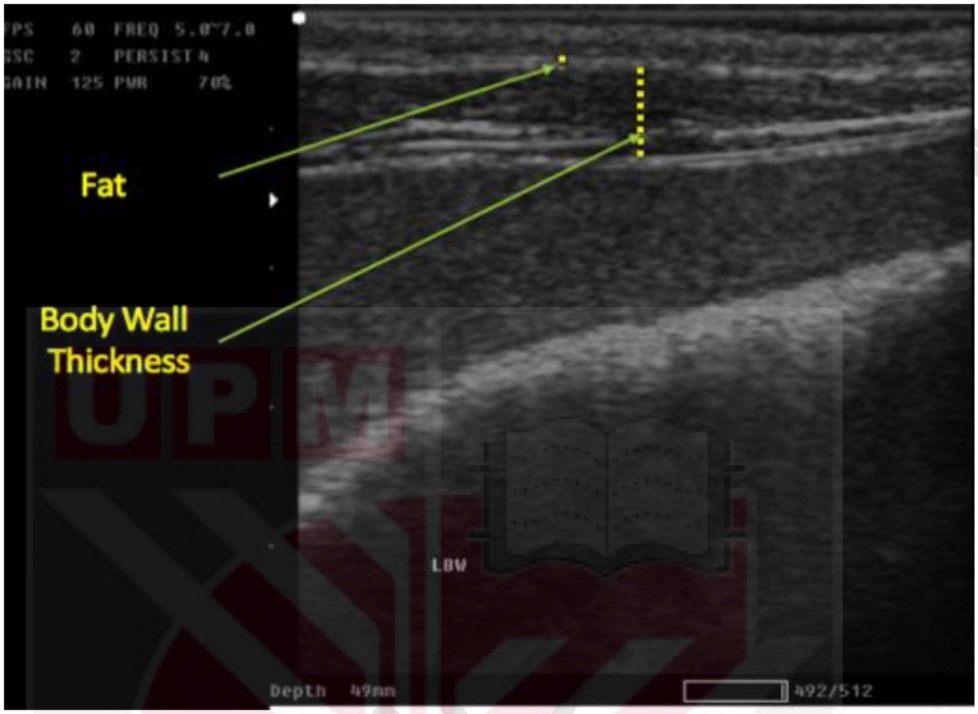

Figure 3: Ultrasound image of the left body wall thickness

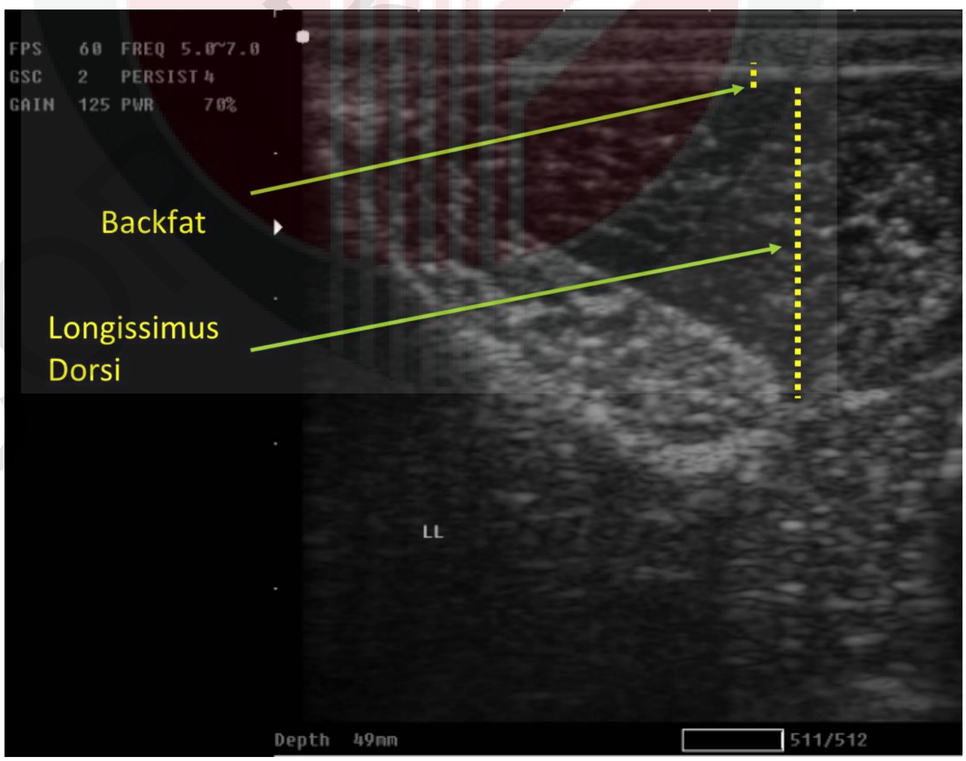

Figure 4: Ultrasound image of the left lumbar region

3.4 Statistical Analyses

The data set was analyzed using IBM SPSS Statistics Version 23 (Armonk, NY: IBM Corp.). Descriptive analysis was performed on the data to determine normality while Pearson's correlation was performed to determine the correlation between ultrasonographic measurements, testicular morphometry and body weight. The ultrasound measurements and testicular morphometry were also tested for normality by using SPSS 23: Kolmogorov-Smirnov[a] and Shapiro-Wilk tests (Table 3). $P < 0.05$ was considered statistically significant.

4.0 Results

The 16 bucks in this study had the following mean characteristics: body weight of 48.47 ± 8.76 kg, thoracic circumference of 85.19 ± 7.55 cm, scrotal circumference of 26.15 ± 2.2 cm, total testicular volume of 177.65 ± 47.63 cm^3, daily sperm output of 3.00 ± 1.14 (10^9/day), scrotal circumference of 26.15 ± 2.23 cm, backfat thickness of left thoracic of 0.114 ± 0.02 cm, backfat thickness of right thoracic of 0.12 ± 0.02 cm, backfat thickness of left lumbar of 0.12 ± 0.02 cm, backfat thickness of right lumbar of 0.12 ± 0.03 cm, longissimus muscle depth of left thoracic 2.07 ± 0.50 cm, longissimus muscle depth of right thoracic of 2.06 ± 0.45 cm, longissimus muscle depth of left lumbar of 2.23 ± 0.52 cm, longissimus muscle depth of right lumbar of 2.26 ± 0.37 cm, left body wall fat thickness of 0.16 ± 0.06 cm, right body wall fat thickness of 0.14 ± 0.05 cm, left body wall thickness of 0.67 ± 0.16 cm, right body wall thickness of 0.63 ± 0.15 cm, left testicular width of 4.81 ± 0.58 cm, right testicular width of 4.80 ± 0.67 cm, left testicular length of 7.78 ± 0.94 cm, right testicular length of 7.95 ± 0.74 cm, left testicular height of 4.36 ± 0.45 cm, right testicular height of 4.45 ± 0.47 cm, left testicular volume of 87.23 ± 25.54 cm^3 and right testicular volume of 90.42 ± 23.24 cm^3.

4.1 Relationship between Body Weight and Longissimus Dorsi muscle depths

Body weight was correlated with longissimus dorsi muscle depths of the left thoracic, right thoracic, left lumbar and right lumbar ($0.543 \leq r \leq 0.722$) (Table 4).

Body Weight with:	Correlation	P-value
Left thoracic	0.722	0.02
Right thoracic	0.543	0.03
Left lumbar	0.674	0.04
Right lumbar	0.689	0.03

Table 2: Relationship between body weight and longissimus dorsi muscle depths

4.2 Relationship between Testicular Morphometry and Ultrasound Measurements

Fat depth of left thoracic was correlated ($r = 0.497$, $P = 0.05$) with right testicular volume. Pearson's correlation also showed that fat depth of right thoracic is correlated ($r = 0.538$, $P < 0.05$) with right testicular length.

4.3 Other Findings

Body weight was highly correlated ($r = 0.824$, $P < 0.05$) with thoracic circumference and the relationship between these two parameters is shown in Figure 5.

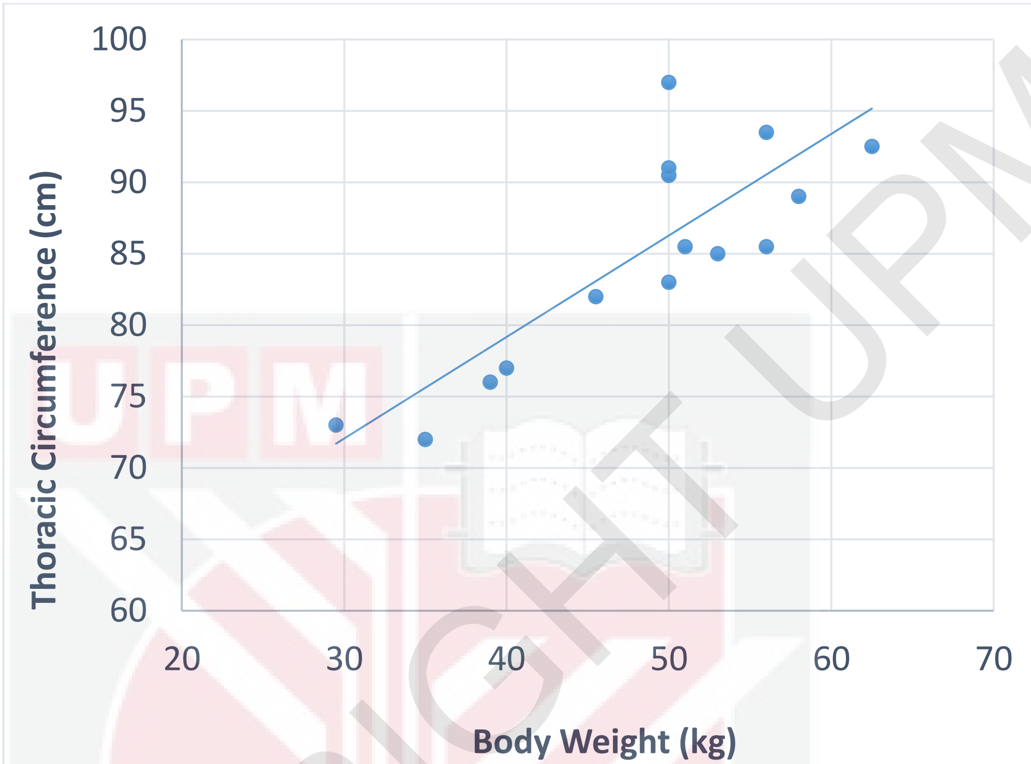

Figure 5: Relationship between thoracic circumference (cm) and body weight (kg).

Thoracic circumference was correlated with: backfat thickness of left and right lumbar ($0.573 \leq r \leq 0.597$), longissimus dorsi muscle depths of left and right thoracic ($0.536 \leq r \leq 0.635$) and longissimus dorsi muscle depths of left and right lumbar ($0.607 \leq 0.635$) (Table 5).

Thoracic Circumference with:	**Correlation**	**P-value**
Backfat Thickness of Left Lumbar	0.573	0.020
Backfat Thickness of Right Lumbar	0.597	0.015
Longissimus Dorsi Muscle Depth of Left Thoracic	0.635	0.008
Longissimus Dorsi Muscle Depth of Right Thoracic	0.536	0.032
Longissimus Dorsi Muscle Depth of Left Lumbar	0.607	0.013
Longissimus Dorsi Muscle Depth of Right Lumbar	0.635	0.008

Table 3: Relationship between thoracic circumference with backfat thickness and longissimus dorsi

There is also correlation (0.468 ≤ r ≤ 0.797) of scrotal circumference with all testicular measurements, except for the right testicular height (Table 6).

Scrotal Circumference with:	**Correlation**	**P-value**
Testicular Width (Left)	0.750	0.001
Testicular Width (Right)	0.739	0.001
Testicular Length (Left)	0.585	0.017
Testicular Length (Right)	0.571	0.021
Testicular Height (Left)	0.787	< 0.05
Testicular Height (Right)	0.468	0.067
Testicular Volume (Left)	0.797	< 0.05
Testicular Volume (Right)	0.731	0.001
Total Testicular Volume	0.784	< 0.05
Daily Sperm Output	0.784	< 0.05

Table 4: Relationship of scrotal circumference with testicular measurements

5.0 Discussion

From this study, the body weight of the animals are correlated with thoracic circumference of the bucks. This is similar to the findings of Khan *et al*. (2006) that showed significant correlation of height at withers and heart girth and bodyweight at 4 to 18 months of age of Beetal goats. There is also a high significant correlation between body weight and heart girth in brown Bengal does and grey Bengal goats (Mukherjee *et al*., 1981; Singh *et al*., 2004).

Body weight of the bucks was correlated with muscle thickness. This is similar to the findings from a study that showed that body weight was highly correlated with longissimus muscle area and backfat thickness in subtropical goat kids (Abdel-Mageed *et al*., 2013). Body weight, body length and heart girth were also highly significant with and used to predict longissimus muscle area in subtropical goat kids (Abdel-Mageed *et al*., 2013). This is also proof that muscle is denser than fat.

Other than that, this study also shows that scrotal circumference was correlated with testicular morphometry which is similar to findings from Raji *et al*. (2008) that showed scrotal circumference is highly correlated with scrotal length and testicular weight in indigenous goat breeds of Nigeria. Larger testes is also correlated with their scrotal circumferences in goats (Alade *et al*., 2006) while semen quality, scrotal circumference and testicular biometry were highly correlated with each other in Bengal goats (Kabiraj, 2011).

However, this study showed that muscle and fat thickness measurements were not correlated with the fertility of animals while body weight of the animals was not correlated with testicular parameters. This is most probably due to the small sample size. Ford *et al*. (2009) had results that showed that body weight accounts for 70% of the variation in scrotal circumference for Boer bucks and only 44% in Kiko bucks which is opposite of what was seen in the current study. The correlation coefficients between testicular measurements and body weight were also high, positive, and highly significant. Males with higher values of testicular parameters had higher body weight in swamp buffalos (Bongso *et al.*, 1984) while scrotal circumference is highly correlated with testis weight and spermatozoa output in growing bulls (Coulter and Foote, 1976 and Amann, 1970).

6.0 Conclusion

There is an association between the measurements of longissimus dorsi muscle with body weight. However, no association was seen between measurements of muscle and fat thickness with testicular morphometry (except backfat thickness of left and right thorax with right testicular volume and length respectively). Finally, scrotal circumference can be used as a measure of fertility.

7.0 Recommendations

7.1 For farmers

For quick evaluation of bucks for genetic value, farmers can measure scrotal circumference to evaluate the fertility rate as results from this study showed that scrotal circumference was correlated with testicular morphometry. Farmers can also use ultrasound to accurately evaluate muscle and backfat depths for the desired carcass traits. Besides that, farmers can also measure thoracic circumference to estimate an animal's body weight because thoracic circumference was highly correlated with body weight. These findings are useful because measurements taken using a flexible plastic tape does not require specific training nor technical skill. They are a quick way to evaluate an animal's fertility rate and body weight.

7.2 For future studies

A larger sample size is recommended as it will improve the accuracy and precision of results. Collecting study subjects from more locations will also reduce biasness in the results. A longer duration of study will definitely help to achieve the goal of a larger sample size from more locations. A backfat infrared scanner can also be used to measure backfat because it is a more practical, less labour intensive and faster method to take measurements. Lastly, measurements of post-slaughter carcass traits will help to determine the accuracy and reliability of using real-time ultrasound to measure muscle and backfat thickness.

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9.0 APPENDICES

UPM
UNIVERSITI PUTRA MALAYSIA

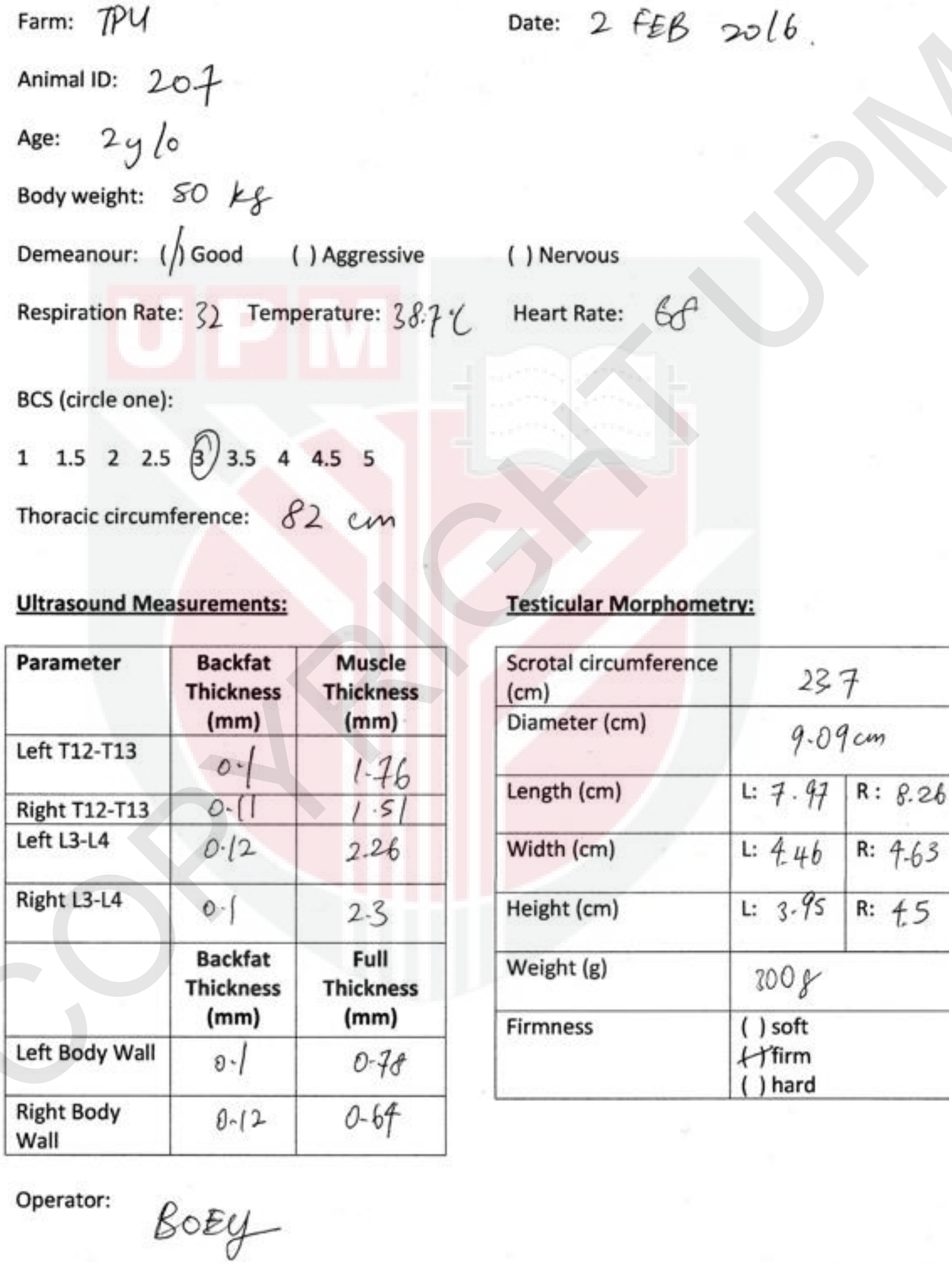
PEJABAT TIMBALAN NAIB CANSELOR (PENYELIDIKAN DAN INOVASI)
OFFICE OF THE DEPUTY VICE CHANCELLOR (RESEARCH AND INNOVATION)

INSTITUTIONAL ANIMAL CARE AND USE COMMITTEE

Date:	21 December 2015
Ref.:	UPM/IACUC/FYP.2015/FPV.023
Project Title:	The Usage of Real Time Ultrasound Measurements of Ribeye Area and backfat Thickness for the Selection of Breeding Goats
Principal Investigator:	Dr. Mark Hiew Wen Han
Associates:	Prof. Madya Dr. Rosnina Hj Yusoff
Student:	Boey Jin Wern
Committee Decision:	The committee has reviewed and approved the proposed animal utilization protocol
AUP No.:	FYP.2015/FPV.023
Project Classification:	Acute
Category of Invasiveness:	B
Source of Animals:	Ladang 16, TPU, UPM ; Ladang Angkat, D'Kebun, Sepang
Number of Animals Approved:	20 Goats
Accommodation:	Reared in Farms
Duration:	11 January, 2016 – 10 July, 2016

(Prof. Dr. Mohd Hair Bejo)
Chairman,
Institutional Animal Care and Use Committee
Universiti Putra Malaysia

Figure 6: Certificate of Institutional Animal Care and Use Committee (IACUC), with the reference number: UPM/IACUC/FYP.2015/FPV.023



Farm: TPU

Date: 2 FEB 2016.

Animal ID: 207

Age: 2y/o

Body weight: 50 kg

Demeanour: (/) Good ( ) Aggressive ( ) Nervous

Respiration Rate: 32 Temperature: 38.7°C Heart Rate: 68

BCS (circle one):

1 1.5 2 2.5 (3) 3.5 4 4.5 5

Thoracic circumference: 82 cm

Ultrasound Measurements:

Parameter	Backfat Thickness (mm)	Muscle Thickness (mm)
Left T12-T13	0.1	1.76
Right T12-T13	0.11	1.51
Left L3-L4	0.12	2.26
Right L3-L4	0.1	2.3
	Backfat Thickness (mm)	**Full Thickness (mm)**
Left Body Wall	0.1	0.78
Right Body Wall	0.12	0.64

Testicular Morphometry:

Scrotal circumference (cm)	23.7	
Diameter (cm)	9.09 cm	
Length (cm)	L: 7.97	R: 8.26
Width (cm)	L: 4.46	R: 4.63
Height (cm)	L: 3.95	R: 4.5
Weight (g)	300 g	
Firmness	( ) soft (/) firm ( ) hard	

Operator: BOEY

Figure 7: Example of a written data sheet

Boey Jin Wern
164668
Pelajar DVM 5
Fakulti Perubatan Veterinar,
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Serdang.

21 Januari 2015

Pemilik/ Pengusaha Ladang,
SABIES MARSIMAN
SG BELANAN
TPLM SG Pelek
Sepang

Tuan/Puan,

Kebenaran untuk melaksanakan projek ilmiah tahun akhir (Final Year Project) untuk kursus perubatan veterinar di Ladang tuan/puan

Merujuk perkara di atas, saya Boey Jin Wern, pelajar tahun akhir dari Fakulti Perubatan Veterinar, UPM, ingin memohon kebenaran melaksanakan projek ilmiah tahun akhir di ladang tuan/puan.

Untuk pengetahuan tuan/puan, butiran projek saya adalah seperti yang berikut:

1. Jumlah haiwan yang diperlukan: 5 Jantan pembaka
2. Sifat perlaksanaan projek: tidak merbahaya atau "invasive" kepada haiwan, tidak melibatkan "injection" atau pengambilan darah.
3. Prosedur projek:
   I. Mencukur bulu haiwan di bahagian belakang badan haiwan (Tulang Thoracic 12 sehingga Lumbar 4)
   II. Mengimbas imej "ULTRASOUND" di bahagian belakang badan haiwan dengan alat mesin ultrasound berfrekuensi rendah. Ini adalah untuk mengukur ketebalan lemak dan daging badan di haiwan tersebut.
   III. Mengukur saiz testis dengan pengukur kain dan kaliper.

Dengan ini, saya berharap tuan/puan boleh membenarkan saya melaksanakan projek ini dan jikalau projek ini berhasil, nama ladang tuan/puan akan dimasukkan dalam pembentangan hasil projek saya kelak nanti.

Yang Benar,

(BOEY JIN WERN)
DVM 5

Figure 8: Letter of approval from private farm manager of Hikmah Cemerlang to conduct our study (first page)


Penyelia Projek

(DR MARK HIEW WEN HAN)

DR. MARK HIEW WEN HAN
Jabatan Pengajian Klinikal Veterinar
Fakulti Perubatan Veterinar
Universiti Putra Malaysia
43400 UPM Serdang, Selangor

Kelulusan pemohonan dari pemilik/pengusaha ladang

Figure 9: Letter of approval from private farm manager of Hikmah Cemerlang to conduct our study (second page)

	Minimum	Maximum	Mean	Std. Deviation	Variance
BODY_WT	29.5	62.5	48.469	8.7606	76.749
THOR_CIRC	72.0	97.0	85.187	7.5540	57.063
BFT_ThorL	.080	.160	.11400	.022030	.000
BFT_ThorR	.070	.160	.11500	.024495	.001
BFT_LumbL	.070	.170	.11938	.024075	.001
BFT_LumbR	.080	.220	.12250	.031728	.001
LM_ThorL	1.180	2.800	2.06644	.498856	.249
LM_ThorR	1.320	2.900	2.05788	.451835	.204
LM_LumbL	.860	3.184	2.23050	.516247	.267
LM_LumbR	1.409	2.680	2.25931	.370495	.137
BodyWallFat_L	.090	.310	.15562	.059774	.004
BodyWallFat_R	.100	.300	.14063	.047395	.002
BodyWallT_L	.480	1.050	.66688	.158775	.025
BodyWallT_R	.440	.890	.63063	.145349	.021
ScroCirc	22.30	30.30	26.1500	2.23219	4.983
TestWidthL	3.80	6.24	4.8050	.57521	.331
TestWidthR	3.10	5.95	4.7994	.66614	.444
TestLengthL	5.84	9.85	7.7769	.94190	.887
TestLengthR	6.29	9.10	7.9481	.73748	.544
TestHeightL	3.40	5.20	4.3575	.45304	.205
TestHeightR	3.59	5.31	4.4513	.47090	.222
TestVolL	42.46	136.35	87.2293	25.54459	652.526
TestVolR	40.77	131.49	90.4199	23.23853	540.029
TotalTestVol	83.23	262.98	177.6492	47.63257	2268.862
DSO	.74	5.05	3.0036	1.14318	1.307
TestWeight_g	180	520	323.75	112.953	12758.333
TestFirmness	2	2	2.00	.000	.000

Table 5: Descriptive analysis

Body_Wt = Body Weight, THOR_CIRC = Thoracic Circumference, BFT = Backfat Thickness, Thor = Thoracic, Lumb = Lumbar, LM = Longissimus Muscle, ScroCirc = Scrotal Circumference, Test = Testicular, Vol = Volume, DSO = Daily Sperm Output

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
BFT_ThorL	.135	16	.200*	.955	16	.579
BFT_ThorR	.105	16	.200*	.977	16	.931
BFT_LumbL	.177	16	.193	.946	16	.432
BFT_LumbR	.282	16	.001	.814	16	.004
LM_ThorL	.131	16	.200*	.955	16	.578
LM_ThorR	.109	16	.200*	.971	16	.852
LM_LumbL	.176	16	.200*	.913	16	.132
LM_LumbR	.199	16	.090	.839	16	.010
BodyWallFat_L	.225	16	.030	.871	16	.028
BodyWallFat_R	.276	16	.002	.642	16	.000
BodyWallT_L	.242	16	.013	.894	16	.064
BodyWallT_R	.162	16	.200*	.923	16	.188
ScroCirc	.134	16	.200*	.975	16	.914
TestWidthL	.101	16	.200*	.961	16	.675
TestWidthR	.161	16	.200*	.933	16	.272
TestLengthL	.189	16	.131	.929	16	.236
TestLengthR	.144	16	.200*	.964	16	.738
TestHeightL	.122	16	.200*	.978	16	.948
TestHeightR	.124	16	.200*	.972	16	.868
TestVolL	.212	16	.054	.941	16	.358
TestVolR	.169	16	.200*	.947	16	.441
TotalTestVol	.180	16	.173	.938	16	.322
DSO	.180	16	.173	.938	16	.322

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Table 6: Tests of normality

BFT = Backfat Thickness, Thor = Thoracic, Lumb = Lumbar, LM = Longissimus Muscle, ScroCirc = Scrotal Circumference, Test = Testicular, Vol = Volume, DSO = Daily Sperm Output