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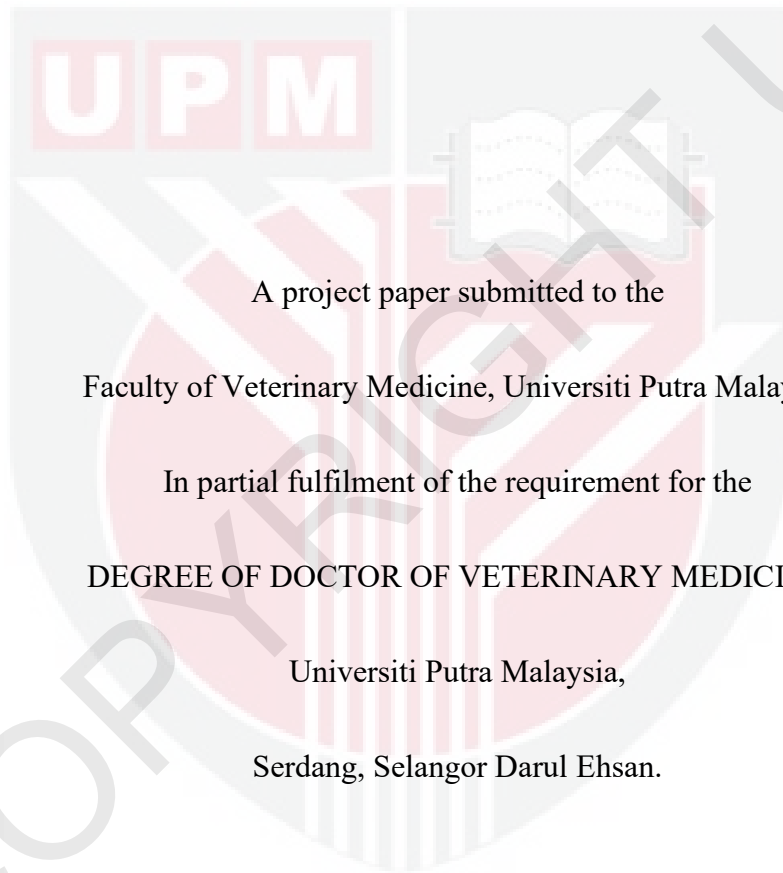
**THE RELATIONSHIP OF INTRAPELVIC AREA AND EXTERNAL  
MORPHOMETRY IN FRIESIAN CROSS CATTLE**

**ALEXANDRIA VERONICA DE LIMA**

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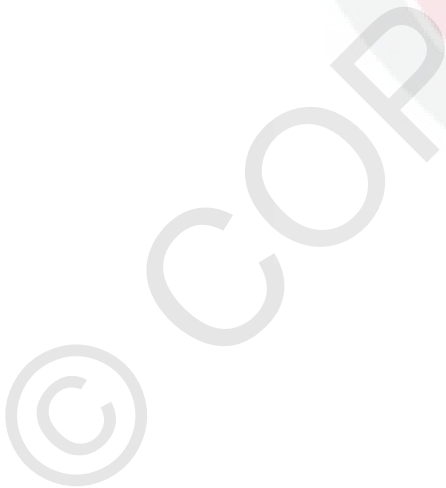
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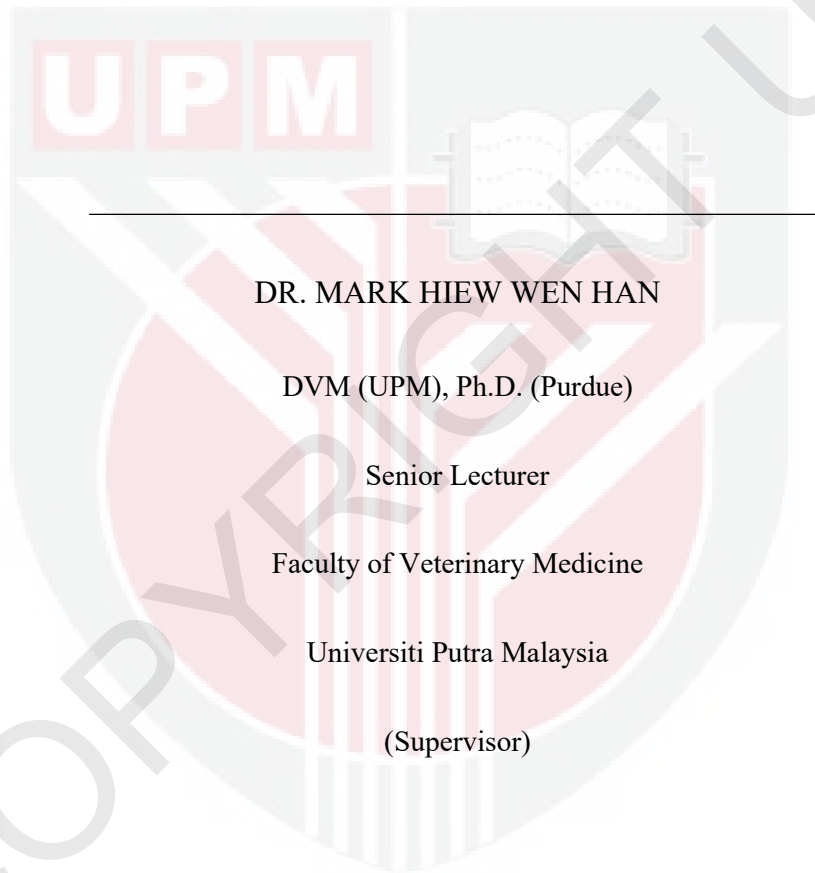
A project paper submitted to the  
Faculty of Veterinary Medicine, Universiti Putra Malaysia  
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Serdang, Selangor Darul Ehsan.

MARCH 2017



## CERTIFICATION

It is hereby certified that I have read this project paper entitled “The relationship of intrapelvic area and external morphometry in Friesian cross cattle”, by Alexandria Veronica de Lima and in my opinion it is satisfactory in terms of scope, quality, and presentation as partial fulfilment of the requirement for the course VPD 4999 – Project



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## DEDICATIONS

This write-up is dedicated to:

My family,

Father

Mother

My sponsors,

John Miles

Karen Miles

Laura Coomber

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

I would like to extend my deepest appreciation and gratitude to all those who have who assisted in making this project paper a reality.

First and foremost, I wish to express my sincerest gratitude to my supervisor, Dr. Mark Hiew Wen Han for his excellent supervision, patience, guidance, motivation, ideas, encouragement, advice, valuable discussions and critical reading of this thesis, all of which he had selflessly granted throughout the duration of this project, and my studies at the faculty. He has dedicated much of his precious time and effort for the whole research which I can never repay. His dynamism, vision, sincerity and motivation have deeply inspired me both in and out of my academic life.

I would also like to thank the staff of the Theriogenology and Cytogenetics laboratory, UPM which includes En. Aizat, for always being there to accompany me in my journey in making this project paper a possibility. Furthermore, I would also extend my gratitude to the veterinary officers of the Large Animal Ward, Dr. Wan and Dr. Azim, as well as En. Nazim for their guidance and support during the project. Without them, this project paper would not have been possible. And for that, I am eternally grateful.

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### LIST OF ABBREVIATIONS

\$	Australian Dollars
%	Percent
£	Great Britain Pounds
Abd	Abdominal circumference
BW	Body weight
cm	Centimeters
cm <sup>2</sup>	Centimeter square
<i>et al.</i>	And others
kg	Kilogram
PA	Pelvic Area
PH	Pelvic Height
PW	Pelvic Width
S.D.	Standard Deviation
S.E.	Standard Error
TcTc	Distance between tuber coxae (Hook width)
Th	Thoracic circumference
TiTi	Distance between tuber ischii (Pin width)
TPU	Taman Pertanian Universiti
UPM	Universiti Putra Malaysia
$\pi$	Pi

**ABSTRAK**

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

HUBUNGAN ANTARA KELUASAN PELVIS DAN MORFOMETRI LUARAN  
PADA LEMBU KACUKAN FRIESIAN

Oleh

Alexandria de Lima

2017

Penyelia: Dr. Mark Hiew Wen Han

Distokia boleh menyebabkan pelbagai masalah kepada induk dan anak lembu dan seterusnya menjejaskan pendapatan penternak. Keluasan pelvis yang kecil mengakibatkan ketidakseimbangan fizikal di antara fetus dengan induk dan menyebabkan distokia. Hubungan di antara ukuran pelvis dalaman dan ukuran morfometrik luar pada 50 lembu kacukan Friesian telah dikaji untuk menentukan keberkesanan penggunaan ukuran-ukuran luaran untuk meramal ukuran dalaman pelvis. Ukuran-ukuran luaran yang telah diambil ialah ukurlilit toraks, ukurlilit abdomen, jarak antara tulang coxae dan jarak antara tulang ischae. Rice pelvimeter telah digunakan untuk mengukur ketinggian dalaman pelvis (PH, cm) dan kelebaran dalaman pelvis (PW, cm). Keluasan pelvis telah dikira menggunakan formula PA (luas pelvis,  $\text{cm}^2$ ) = PH  $\times$  PW. Korelasi Pearson (SPSS v22) menunjukkan bahawa semua ukuran morphometric luar berkait dengan ukuran pelvis dalaman ( $0.43 < r < 0.60$ ,  $P <$

0.05 ). Analisa regresi menunjukkan bahawa parameter pelvis dalaman boleh diramal dari berat badan dan ukuran morfometrik luar. Kesimpulannya, terdapat hubungan antara ukuran pelvis dalaman dan morfometri luaran. Model yang diperoleh membolehkan ukuran morfometri luaran digunakan sebagai peramal ukuran pelvis dalaman.

Keywords: distokia, kacukan Friesian, ukuran pelvis dalaman, morfometri luar, pelvimeter



**ABSTRACT**

Abstract of the project paper presented to the Faculty of Veterinary Medicine, Universiti Putra Malaysia in partial requirement for the course VPD 4999 – Final Year Project

**THE RELATIONSHIP OF INTRAPELVIC AREA AND EXTERNAL MORPHOMETRY IN FRIESIAN CROSS CATTLE**

By

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2017

Supervisor: Dr. Mark Hiew Wen Han

Dystocia causes adverse effects to both the dam and calf which results in a significant economic impact to the farmer. Small pelvic area in dams is an important contributor to dystocia causing a physical incompatibility with the fetus or feto-pelvic disproportion. The relationship between intrapelvic measurements and external morphometric measurements was studied in 50 Friesian cross cattle to determine the usage of external measurements as predictors for intrapelvic parameters. External morphometric parameters taken were thoracic circumference, abdominal circumference, distance between tuber coxae and distance between tuber ischii. A Rice pelvimeter was used to measure the intrapelvic parameters of pelvic height (PH, cm) and pelvic width (PW, cm). The pelvic area (PA, cm<sup>2</sup>) was calculated using the

formula  $PA = PH \times PW$ . Pearson's correlation (SPSS 22) showed that all external morphometric measurements were correlated with intrapelvic measurements ( $0.43 < r < 0.60$ ,  $P < 0.05$ ). Regression analyses showed that the internal pelvic parameters can be predicted from body weight and external morphometric measurements. In conclusion, there was an association between the intrapelvic measurements and the external morphometry and by using the models derived, the intrapelvic measurements can be predicted from the external morphometry.

Keywords: dystocia, Friesian cross, intrapelvic measurements, external morphometry, pelvimeter

## 1.0 Introduction

Parturition in cattle is known to be a complicated physiological process and the onset is generally accepted to be initiated by the fetus (Thorburn *et al.*, 1977; Thorburn, 1979). In normal circumstances, this complicated process involving several hormonal interactions should conclude without any human interference, leaving a healthy cow with a vigorous calf. However, in reality a large proportion of calvings require assistance to varying degrees that may result in a stillborn calf (Meijering, 1984). Domestication and breeding programmes in the dairy industry select for cows that produce calves that are relatively larger when compared to their dams; a regular occurrence in cattle compared to most other mammals (McClintock, 2004).

As dystocia is highly related to the pelvic area (Price and Wiltbank, 1978), being able to measure the pelvic dimensions is beneficial. The process of measuring the internal and external capacity and diameter of the pelvis is known as pelvimetry (Studdert *et al.*, 2011). This is elucidated in studies which reveal that there is value in using external pelvimetry as a predictor for the internal pelvic measurements (Murray *et al.*, 2002), while others show that withers height and heart girth were the best predictors of internal pelvic sizes (Kolkman *et al.*, 2012; Coopman *et al.*, 2003). Hence, it would be easier if the farmer had an alternate method to measure internal pelvic dimensions, such as predicting those dimensions through measurements of external morphometry which could be done directly using measuring tape. Therefore, the ability to accurately determine the possibility of dystocia will allow early and appropriate intervention, which then decreases the morbidity and mortality of the dam

and fetus, improving animal welfare and reducing economic losses (Linden *et al.*, 2009).

There is a need for information regarding associations between internal pelvic measurements and external morphometry, which may have value in determining dams with larger pelvic opening hence an increased calving ease (Bellows *et al.*, 1971). Currently, no research has been done to study the association between the intrapelvic measurements and the external morphometric measurements in Friesian cross cattle in Malaysia. Therefore, the objective of this study was to determine the relationship between intrapelvic parameters with morphometric measurements, age, body weight and body condition score in Friesian cross cattle. It is hypothesized that there is an association between the intrapelvic measurements and external morphometry in Friesian cross cattle.

## 2.0 Literature Review

### 2.1 Dystocia

Dystocia, defined as delayed or difficult parturition (Mushtaq, 2016), is usually classified into two main causes which are direct factors and indirect factors (Meijering, 1984). The former usually being anatomical and physiological factors such as malpresentation of the calf in the birth canal and uterine torsion in the dam. The latter is related to phenotypic effects that are related to the calf such as calf birth weight, multiple calvings and perinatal mortality, as well as phenotypic effects associated with the cow such as cow pelvic area, cow body weight at calving, cow body condition score, gestation length and calving assistance. Indirect factors also include non-genetic factors such as cow age, parity of cow, calf sex, nutrition and other disorders, while genetic factors involve cow, bull and calf breeds (Zaborski *et al.*, 2009). The most common cause of dystocia is a physical incompatibility between the size of the fetus and maternal pelvic size, also known as feto-pelvic incompatibility. The pelvic size of the dam is mainly influenced by the stage of maturity of the cow. As a result, a smaller pelvic size in heifers contributes to the higher incidence of dystocia (Haskell and Barrier, 2014) and vice versa where dams with larger pelvic openings experience less calving difficulty (Barrier *et al.*, 2013).

### 2.2 Breed Comparisons

Several studies have shown that there are significant differences in pelvic dimensions between breeds of beef and dairy cattle (Ramin *et al.*, 1995; Laster 1974; Meijering and Pastma, 1984; McElhenney *et al.*, 1985). There are also differences

between herds within breeds, purebreds and crossbreeds, and small breeds and large breeds. The pelvic height and pelvic width increase greatly with advancing age, which shows that the pelvic area is larger in mature cows in comparison to heifers. The mean pelvic heights in beef and dairy heifers can vary from 13.5 cm to 19.3 cm, the pelvic width from 12.6 cm to 18 cm, and the mean pelvic area from 170 cm<sup>2</sup> to 290 cm<sup>2</sup>.

### **2.3 Impact of Dystocia on the Dam**

The occurrence of dystocia has shown to have an adverse effect on the reproductive performance of dairy cows, where the first estrus, days open and the calving interval were significantly longer (Gaafar *et al.*, 2010). Fertility is further impaired as a result of dystocia as it causes a reduction in conception rate and an increase in the number of services per conception (Lopez de Maturana *et al.*, 2007). Total milk yield also tends to be lower in cows that have experienced dystocia at calving compared to those that calved normally (Berry *et al.*, 2007). Furthermore, there is a significant increase in the mortality rate of cows experiencing dystocia in comparison to those that calved without assistance and the number is highest in cows that required serious intervention during parturition (Dematawewa and Berger, 1997).

### **2.4 Impact of Dystocia on the Calf**

The majority of stillbirths are reported to be a direct result of dystocia (Meyer *et al.*, 2000; Lombard *et al.*, 2007). During parturition, there are several dramatic physiological changes that can have adverse effects on the fetal oxygen concentration (Lombard and Garry, 2013). The fetus can experience neonatal asphyxia during the

calving process due to hypoxia, decreased blood flow as a result of occlusions of the placenta, or ischemia. Hypoxia can progress to anoxia, which can be prolonged with instances of dystocia resulting in fetal death (Bluel *et al.*, 2008). The calf can also have hypercapnia, which can cause respiratory acidosis. However, during dystocia, respiratory acidosis will be pronounced and in addition to this, the hypoxia can lead to anaerobic metabolism within the body that results in metabolic acidosis. The acidotic condition of the foetus can negatively affect the central nervous system resulting in lowered vigour, depression and decreased physical activity, which is referred to as 'weak calf syndrome' or 'dummy calf syndrome' (Ravary-Plumioën, 2009). The dystocic calves were slower to express most of the neonatal behaviours, particularly those that lead up to reaching the udder, and usually lay recumbent (Barrier *et al.*, 2012). This results in the failure of transfer of passive immunity as the calf is unable to absorb an adequate quantity of colostrum (Johnson *et al.*, 2007; Weaver *et al.*, 2000). This has been linked with an increase in calf morbidity and mortality and a reduction in the calf growth rate (Robison *et al.*, 1988; Donovan *et al.*, 1998).

## **2.5 Economic Impacts**

In a United Kingdom dairy herd, the total cost of a slightly difficult calving was estimated to be roughly £110, while a more serious difficult calving can range from £350 to £400. This takes into account the labour and veterinary costs, including the cost of cesarean deliveries, the mortality of dams and calves and the culled cows, the losses incurred due to a decreased milk production and poor reproductive performance (McGuirk *et al.*, 2007). In Australian Holstein Friesian herds, the cost of

dystocia for a herd can go up to \$5100 per year, where 30% of the losses is due to reduced fertility, 20% due to culling or dam death, about 10% due to veterinary costs and labour costs at 20%. The cost of dystocia in primiparous cows was about \$48.49 and \$19.15 in mature cows. The overall losses associated with calving difficulties in the Australian dairy industry can be estimated to be in excess of \$44 million annually (McClintock, 2004). In a study by Dematewewa & Berger (1997), the estimated costs of dystocia were \$0.00, \$50.45, \$96.48, \$159.82 and \$379.61 for dystocia scores 1 to 5 (1 representing no problem to 5 representing extreme difficulty) which showed that losses incurred increase as the difficulty of calving increases.

## 2.6 Pelvimetry

Internal pelvimetry involves the measurement of the pelvic height and the pelvic width which allows the pelvic area to be determined (Rice and Wiltbank, 1972; Bellows *et al.*, 1971; Morrison *et al.*, 1986; Johnson *et al.*, 1988). Internal dimensions are measured using a sliding calliper device that is referred to as a Rice pelvimeter. Other instruments have also been developed such as the Krautmann-Litton Bovine pelvic meter and the EquiBov Bovine pelvimeter (Deutscher, 1987). The external pelvimetry is mostly done in correlation to the internal pelvic dimensions where the measurements are taken on the external body of the animal; for example, the pin width, hook width, rump length and hook to pin length (Bellows *et al.*, 1971; Johnson *et al.*, 1988; Coopman *et al.*, 2003). Pelvimetry is a relatively simple and reliable method to determine pelvic parameters of cows with the basis that the larger the pelvic area, the lower the calving difficulty. However, a farmer would require the services of a

veterinarian with the skills and knowledge to perform this technique, which would increase costs (Kolkman *et al.*, 2012).

## 2.7 Welfare

The measurement of internal pelvic parameters is invasive and carries a risk of trauma to the rectal mucosa. It has been recommended to administer epidural anaesthesia which allows the cow to stand normally without arching her back or attempting to strain. However, the administration of the epidural anaesthesia requires specialised veterinary training (Murray *et al.*, 2002). Despite the risk for injury, if the internal pelvimetry is done properly and gently with the use of adequate quantities of lubrication, damage to the rectal mucosa can be prevented (Hiew and Constable, 2015).

### 3.0 Materials and Methods

Data was collected from 50 Friesian cross dairy cattle (23 from Ladang 16, Taman Pertanian Universiti (TPU), Universiti Putra Malaysia (UPM), 13 from a dairy cattle farm in Bangi, Selangor and 14 from another dairy cattle farm in Lenggeng, Negeri Sembilan that were part of the Ladang Angkat Programme) within a period of 2 weeks using convenience sampling. All of the cows were between 2-14 years of age and weighed between 200-750 kg. The ages of the cows at TPU were gathered from records, whereas the ages of the other cattle were determined using dentition (Lawrence *et al.*, 2001). This study was approved by the Institutional Animal Care and Use Committee (IACUC), with the reference number: UPM/IACUC/FYP.2016/FPV.71

The external morphometry parameters measured were thoracic circumference, abdominal circumference, hook width and pin width. Thoracic circumference (Figure 1) was determined using a measuring tape (tailor fibreglass measuring tape) placed immediately caudal to the scapula and forelimbs. The abdominal circumference (Figure 2) was determined by placing the same tape cranial to the hind limbs, tuber coxae and udder, and was measured in centimetres (West, 1997) (Figure 3). The hook width (Figure 4) was measured using the linear distance between the most lateral surfaces of the wings of the ileum or tuber coxae while the pin width (Figure 5) was the linear distance between the most lateral surfaces of the tuber ischium (Singh *et al.*, 1984) (Figure 6). These distances were measured in centimetres using straight rulers and a tape measure whereby one straight metal ruler was placed vertically at the lateral aspect of the tuber coxarum or tuber ischium and the other straight metal ruler was placed vertically at the lateral aspect of the opposite tuberosity with the measuring tape

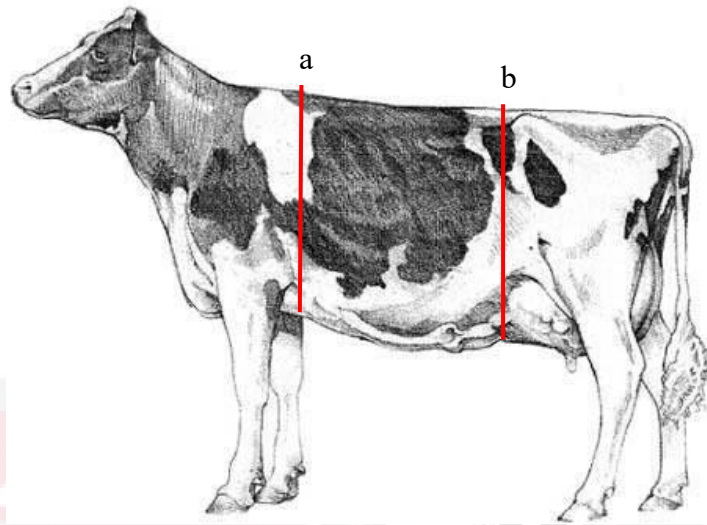
stretched tautly between the two rulers (Craig, 1941). The body condition score was measured using a 5-point scoring method with quarter-point increments from an established scoring system from Elanco Animal Health (1997). The body weight was determined by measuring the thoracic circumference using a calibrated heart girth tape (Wintape Measuring Tape), in kilograms.



**Figure 2:** Measuring the thoracic circumference



**Figure 1:** Measuring the abdominal circumference



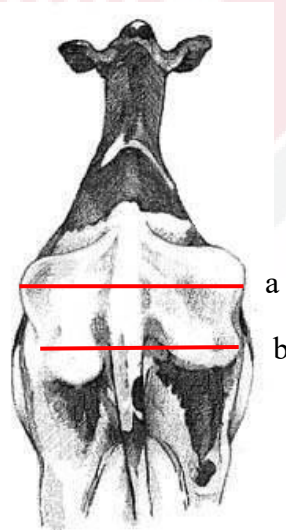
**Figure 3:** External morphometry; a. Thoracic circumference, b. Abdominal circumference (Elanco Animal Health, 1997)



**Figure 4:** Measuring the distance between the tuber coxae



**Figure 5:** Measuring the distance between the tuber ischii



**Figure 6:** External morphometry; a. The distance between tuber coxae, b. The distance between tuber ischii (Elanco Animal Health, 1997)

The internal pelvimetry was measured using a Rice pelvimeter (Lane Manufacturing Inc., Colorado, U.S.A.) (Figure 3) that provides measurements in centimetres with a gradient of 0.25 cm. Faeces were manually evacuated from the rectum and the pelvimeter was well lubricated using an aqueous based lubricant (BOVIVET Gel granulate). The closed pelvimeter was gently and slowly introduced into the rectum in a closed position with one hand - the arm of the investigator was protected using a disposable rectal sleeve (KRUTEX super sensitive disposable examination gloves). The pelvic height (Figure 8) was measured by opening the device within the pelvic canal and recording the distance between the dorsal aspect of the pubic symphysis on the floor of the pelvis and the ventral aspect of the sacral vertebrae. The pelvimeter was then closed and rotated 90° to measure the pelvic width, (Figure 9) which is defined as the horizontal distance at the widest point between the left and right ileal shafts at right angle to where the height was measured (Bellows *et al.*, 1971). One limitation of the Rice pelvimeter is that it has a maximum reading of 20 cm, but in this study none of the cows had pelvic measurements that exceeded 20 cm. The intrapelvic area was calculated as the area of a rectangle by multiplying the pelvic width and the pelvic height (Gaines *et al.*, 1993; Ramin *et al.*, 1995; Green *et al.*, 1988). The intrapelvic area can also be measured as an ellipse with the equation  $PA = PH \times PW \times \pi/4$  (David, 1960). Despite the higher degree of accuracy offered by the ellipsoidal equation, the rectangle equation was used for calculation because the ellipsoidal equation offered no advantage of predicting the risk of dystocia and did not differ when ranking pelvic size (Rice and Wiltbank, 1972).



**Figure 7: Rice Pelvimeter**



**Figure 8: Pelvic Height; a. ventral aspect of midsacrum, b. ventral aspect of pubic symphysis**



**Figure 9: Pelvic Width**

All measurements taken were measured three times consecutively by the same person and the resulting mean values were used for analyses.

Data was placed on a data capture sheet for each farm, and transferred to an Excel spread sheet (Microsoft Office Excel, 2016). The data was then analysed using IBM SPSS Statistics version 22. Data was expressed as mean  $\pm$  standard deviation. Shapiro-Wilk test was used as a numerical means of assessing normality and the output of a normal Q-Q plot was used to determine this graphically. One-way analysis of variance (ANOVA) was conducted to examine the relationship of age categories (2 - 3 years, 3 - 4 years, 4 - 5 years, 5 - 6 years and  $>$  6 years) on the external morphometry and internal pelvic measurements. Pearson product-moment correlation coefficient ( $r$ ) was used to determine the association between internal pelvic dimensions and external morphometry, age, body weight and body condition score. Regression analysis was

performed to determine the ability of external morphometry, age, body weight and body condition score to predict internal pelvic dimensions. The data collected were used to develop multiple regression equations that estimate the inner pelvic sizes from the external measurements.



#### 4.0 Results

The descriptive statistics for age, body weight, body condition score, external morphometry and internal pelvic measurements for the 50 Friesian cross cows are given in Table 1.

**Table 1:** Age, body condition score, body weight, external morphometry and internal pelvic measurements for 50 Friesian cross cattle.

Trait	Minimum	Maximum	Mean	S.E.	S.D.	Median
Age (months)	24.00	165.00	60.16	4.17	29.16	54.00
Body condition score (1-5)	2.50	4.00	3.21	0.05	0.36	3.25
Body weight (kg)	277.3	722.7	456.9	14.0	98.7	437.8
Thoracic circumference (cm)	151.5	206.2	177.0	1.8	12.4	175.9
Abdominal circumference (cm)	152.0	227.8	189.2	2.2	15.8	189.4
Distance between tuber coxae (cm)	38.3	57.2	47.5	0.6	4.4	47.7
Distance between tuber ischae (cm)	20.0	45.6	31.5	0.8	5.7	31.8
Pelvic height (cm)	12.42	19.50	16.64	0.22	1.59	17.13
Pelvic width (cm)	11.67	19.08	15.64	0.24	1.69	15.50
Pelvic area (cm <sup>2</sup> )	158.31	398.86	263.28	7.21	51.02	262.43

There was no significant difference ( $P = 0.65$ ) between the mean pelvic area of the cows sampled and the minimum pelvic size of Friesian-Holsteins that was determined to have a low incidence of dystocia, whereby cows which had pelvic sizes greater than the determined value of  $260 \text{ cm}^2$  would have a reduced risk of dystocia (Hoffman *et al.*, 1996). The mean pelvic size of the sampled cows was  $3.28 \text{ cm}^2$  larger than the determined value of  $260 \text{ cm}^2$ . In this sample, 24 cows out of the 50 (48%) had pelvic areas below  $260 \text{ cm}^2$ , with the smallest pelvic area being  $158.31 \text{ cm}^2$ .

#### 4.1 Analysis of variance (ANOVA)

The analysis of variance showed that there was a statistically significant difference between the age and: thoracic circumference ( $P = 0.008$ ), abdominal circumference ( $P = 0.046$ ), distance between tuber coxae ( $P = 0.046$ ) and distance between tuber ischii ( $P = 0.009$ ). However, there was no difference when it came to pelvic height, pelvic width and pelvic area ( $P > 0.05$ ) amongst the age categories. The post-hoc comparisons using the Tukey HSD test gave indications that the means for thoracic circumference was lower for the age categories 2 – 3 years ( $170.1 \pm 10.7 \text{ cm}$ ,  $P = 0.021$ ), 3 – 4 years ( $172.4 \pm 12.4 \text{ cm}$ ,  $P = 0.017$ ) compared to the category > 6 years ( $189.4 \pm 12.9 \text{ cm}$ ). There was a significant difference ( $P = 0.034$ ) for abdominal circumference when comparing age category 4 – 5 years ( $180 \pm 13.3 \text{ cm}$ ) to > 6 years ( $201.6 \pm 15.3 \text{ cm}$ ).

#### 4.2 Pearson's Product-Moment Correlation

Table 2 illustrates the correlations between the external morphometry and internal pelvic dimensions, using Pearson's Product-Moment Correlation. The external morphometric parameters of thoracic circumference, abdominal circumference, distance between tuber coxae, and distance between tuber ischii have a moderately, positive correlation with the internal pelvic measurements of pelvic height, pelvic width, and pelvic area that were statistically significant ( $P = 0.01$ ). Age in months had a weak and positive correlation with pelvic height ( $r = 0.35$ ) and pelvic area ( $r = 0.29$ ) at the level of  $P = 0.05$ . However, there was no correlation between age and pelvic width ( $r = 0.25$ ,  $P = 0.86$ ).

**Table 2:** Correlations between the external morphometry and internal pelvic parameters.

Traits	Pelvic Height	Pelvic Width	Pelvic Area
Thoracic circumference	0.50**	0.53**	0.48**
Abdominal circumference	0.60**	0.52**	0.52**
Distance between tuber coxae	0.46**	0.49**	0.43**
Distance between tuber ischae	0.47**	0.54**	0.50**

\*\* Correlation coefficient ( $r$ ) is significant at the 0.01 level (2-tailed)

Body weight (kg) showed a moderate positive correlation with pelvic height ( $r = 0.40$ ), pelvic width ( $r = 0.50$ ) and pelvic area ( $r = 0.44$ ) at a level of  $P = 0.01$ . Body weight also displayed a very strong positive correlation with: thoracic circumference ( $r = 0.99$ ), abdominal circumference ( $r = 0.76$ ), distance between tuber coxae ( $r = 0.77$ ) and the distance between tuber ischae ( $r = 0.73$ ) at a level of  $P = 0.01$ . Body condition

score showed no significant correlation with intrapelvic height ( $r = 0.11$ ,  $P = 0.55$ ), intrapelvic width ( $r = -0.10$ ,  $P = 0.47$ ) and intrapelvic area ( $r = -0.08$ ,  $P = 0.60$ ).

There were positive correlations between age in months and thoracic circumference, abdominal circumference, distance between the tuber coxae and distance between tuber ischii, all of which were significant at the level of  $P = 0.01$  (Table 3). There is also a significant correlation between age in months and the body weight ( $r = 0.58$ ,  $P < 0.0005$ ).

**Table 3:** Correlations between the age (months) and external morphometry in 50 Friesian cross cattle.

Age (months) with	Correlation	P-value
Thoracic circumference	0.56	< 0.0005
Abdominal circumference	0.48	< 0.0005
Distance between tuber coxae	0.45	< 0.0005
Distance between tuber ischae	0.63	< 0.0005

The correlations between the external morphometry measurements are given in Table 4. There is significant, strong and positive correlation between each of the external morphometric measurements that were taken, where  $P < 0.0005$  for all variables.

**Table 4:** Correlations between the external morphometry of 50 Friesian cross cattle.

Traits	Thoracic circumference	Abdominal circumference	Distance between tuber coxae
Abdominal circumference	0.76**	-	-
Distance between tuber coxae	0.78**	0.72**	-
Distance between tuber ischae	0.72**	0.64**	0.77**

\*\* Correlation coefficient (r) is significant at the 0.01 level (2-tailed)

### 4.3 Regression analysis

Several models were developed using linear and multiple regression analyses, which can be used to predict internal pelvic parameters using the external morphometric measurements (Table 5). The best predictors for pelvic height were body weight and the external parameters of thoracic circumference and abdominal circumference, whereby these parameters explain 58% of the variability of pelvic height. For pelvic width, the ideal predictor would be the distance between the tuber ischii which explains 29% of the variability of the pelvic width. Body weight, thoracic circumference and the distance between tuber ischii were the best predictors for pelvic area whereby they explain 40% of the variability of the pelvic area.

**Table 5:** Models to predict inner pelvic sizes from easily accessible external morphometry

Y	Model	R <sup>2</sup>	S.E.
Pelvic Height	$Y = -50.57 - 0.06 \times BW + 0.47 \times Th + 0.05 \times Abd$	0.58	1.13
	$Y = -48.90 - 0.05 \times BW + 0.52 \times Th$	0.40	1.25
	$Y = 5.13 + 0.06 \times Abd$	0.37	1.38
Pelvic Width	$Y = 6.74 + 0.19 \times TcTc$	0.24	1.49
	$Y = 10.61 + 0.16 \times TiTi$	0.29	1.45
Pelvic Area	$Y = -1549.01 - 1.54 \times BW + 14.22 \times Th$	0.33	42.51
	$Y = -1585.33 - 1.56 \times BW + 13.22 \times Th + 1.17 \times Abd$	0.39	41.15
	$Y = -1610.11 - 1.70 \times BW + 14.38 \times Th + 3.37 \times TiTi$	0.40	40.78

## 5.0 Discussion

This study was conducted to determine the relationship between external morphometry and internal pelvic measurements in cattle. This study also aimed to investigate the usage of external morphometry to accurately predict internal pelvic measurements to make an early diagnosis of potentially problematic cattle with small pelvic areas which is known to be a cause of dystocia (Haskell and Barrier, 2014).

From this study, correlations were shown to exist between all the external morphometric measurements and the internal pelvic measurements. This is consistent with the findings of Murray *et al.* (2012), whereby the distance between tuber coxae and distance between tuber ischii were correlated with the internal pelvic parameters as well as with Kolkman *et al.* (2012), whereby pelvic parameters were correlated with thoracic circumference. On the other hand, another study found that there was no significant relationship among external body measurements and pelvic dimensions (Brown *et al.*, 1971).

In this study, there was a positive and moderate correlation between the body weight and internal pelvic parameters ( $0.40 < r < 0.50$ ). This is consistent with the findings of Bellows *et al.* (1971) which showed a significant positive correlation of the body weight and the internal pelvic parameters of pelvic height, pelvic weight and pelvic area for Hereford and Angus dams.

There was a positive and weak correlation between age in months and the internal pelvic measurements of pelvic height and pelvic area ( $0.29 < r < 0.35$ ), but not with pelvic width. Age in months also correlated with all external morphometry. Coopman *et al.* (2003) reported that the internal pelvic measurements and external

body traits were positively correlated with age in months which is similar to the findings of this study. The weak correlation observed in this study would be due to aging of the cattle using dentition which can be a subjective.

There was a negative correlation between the body condition score and pelvic height and pelvic area, and a positive correlation with pelvic width, however they were not significant. This could be because body condition score is a subjective measure of the body fat scores, so there is poor repeatability between different observers. However, a study by Bellows *et al.* (1971) showed a positive correlation between pelvic area and condition score, while Micke *et al.* (2010) stated that an increase in body condition score increases the risk of dystocia.

External morphometry measurements can be used to pelvic measurements indirectly and this is convenient as they are more easily attained compared to internal pelvimetry. In this instance, the farmer does not require any veterinary skills and only needs minimal equipment (flexible measuring tape and rulers) to obtain measurements of the external morphometry. There is also limited risk to the animals involved, because using the pelvimeters comes with the risk of rectal mucosal damage, besides being a quick and easy way to estimate the pelvic.

Dystocia is a result of several factors, with one of them being a small pelvic size. Use of pelvic area to identify the possibility of dystocia is somewhat debated as it accounts for only a small part of the factors that leads to dystocia (Bellows *et al.*, 1971; Gaines *et al.*, 1993; Meijering, 1984). Nonetheless, the pelvic area is one of the available measurements that individuals can use to actively manage the risk of dystocia occurring in cattle (Micke *et al.*, 2010). By being able to identify cattle that are at a

higher risk for dystocia by using pelvic area measurements, it will allow for increased supervision during the expected time of calving and enables timely intervention in cases that require assistance. This avoids possible injuries or trauma to the cattle which could be a cost-effective management strategy and one that promotes animal welfare.



## 6.0 Conclusion

This study shows that by using the models derived, internal pelvic measurements can be predicted with external morphometry. This allows the identification of cattle that may have calving difficulties due to a smaller pelvic area.



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## 7.0 Recommendations

A larger sample size is recommended as it will improve the accuracy and precision of the study. Besides that, collecting study subjects from numerous different locations will reduce biasness and help create a model which is representative of the Friesian cross breed in Malaysia.

Instead of using the ruler and tape measure method as used in this study, Vernier callipers would provide more accurate measurements. More external morphometric measurements could be taken, such as withers height that is defined as the distance from the top of the shoulder to the ground, hook height that is defined as the distance from the top of the tuber coxae to the ground and rump length which is the distance from the tuber coxarum to the ipsilateral tuber ischium.

The intrapelvic measurements can also be taken using other pelvimeters, such as the Krautmann-Litton bovine pelvic meter (Jorgensen Laboratories, Inc., Loveland, CO) and the Equibov Bovine Pelvimeter (Equibov, Ontario, Canada), which gives a higher degree of accuracy and could be used in comparison with the Rice pelvimeter.

Future studies looking at the correlation of dystocia scores, pelvic area and size of calves (Hiew *et al.*, 2016) could also be done in order to come up with better and more robust models to predict dystocia in Friesian cross cattle in Malaysia.

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## 9.0 Appendices

### 9.1 Certificate of Institutional Animal Care and Use Committee (IACUC), with the reference number: UPM/IACUC/FYP.2016/FPV.71



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

#### INSTITUTIONAL ANIMAL CARE AND USE COMMITTEE

Date: 30 December 2016

AUP No.: FYP.2016/FPV.71

Project Title: The relationship of intrapelvic area and external morphometry in cattle

Principal Investigator: Dr. Mark Hiew

Associate: -

Student: Alexandria V. de Lima

Committee Decision: The committee has reviewed and approved the proposed animal utilisation protocol, subject to relevant permit and/ or owner's consent.

Project Classification: Acute

Category of Invasiveness: B

Source of Animals: (1) Ladang Angkat, University Veterinary Hospital, Faculty of Veterinary Medicine, Universiti Putra Malaysia  
(2) Taman Pertanian Universiti, Universiti Putra Malaysia

Number of Animals Approved: 100 Cattles

Duration: 9 January, 2017 – 12 February, 2017

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

## 9.2 Aging using dentition

1684

Lawrence et al.

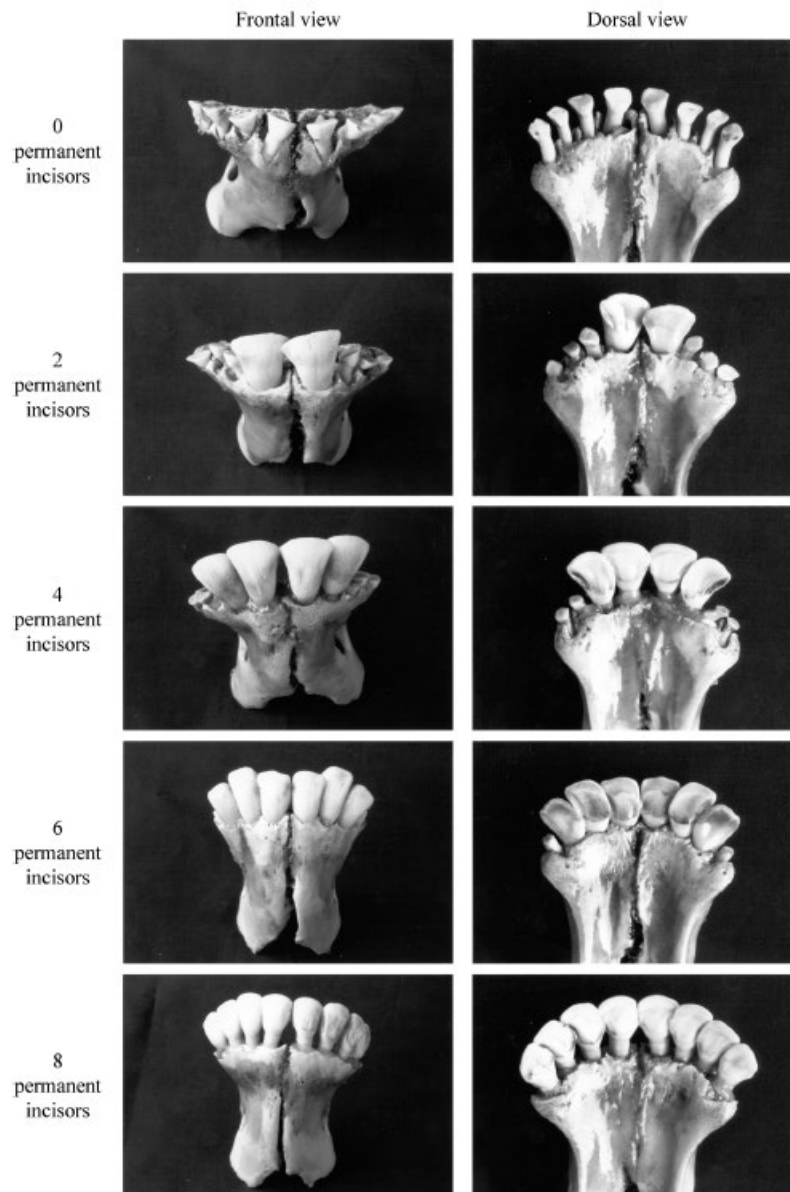


Figure 1. Frontal and dorsal views of the lower jaw, with each set of incisors up and in wear.

(Lawrence et al., 2001)

### 9.3 Body Condition Score

#### THE 5-POINT BODY CONDITION SCORING SYSTEM

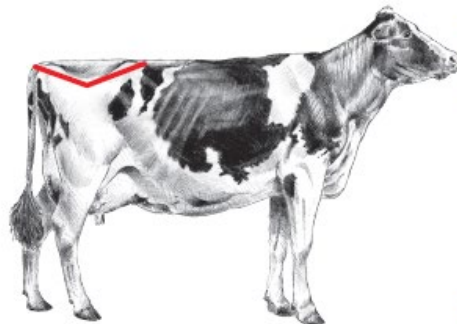
Body condition scoring (BCS) refers to the relative amount of subcutaneous body fat or energy reserve in the dairy cow. BCS is an important management tool for maximizing milk production and reproductive efficiency while reducing the incidence of metabolic and other peripartum diseases.

Most body condition scoring systems use a 5-point scoring method with quarter-point increments

This system concentrates its accuracy toward the mid-range scores (2.50 to 4.00), which includes most cows. This mid-range is the most critical for making management decisions. Scores outside this range indicate significant problems (1.00 denotes a very thin cow, while 5.00 indicates an excessively fat cow). Exact scoring of BCS extremes is less critical. BCS is not an indication of energy balance. You should monitor changes in body condition over time.

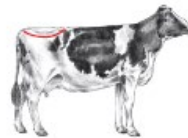
Begin by viewing the cow's pelvic area from the side

Check the line formed from hooks to the thurl to the pins to determine if it is angular (V-shaped) or crescent (U-shaped). This is the most difficult part of the scoring process, especially if the cow is near the 3.00 or 3.25 score.



≤ 3.00: Flattened V

If the line forms a flattened V, then BCS ≤ 3.00. Move to the rear of the cow to view the hooks, then pins and short ribs to determine BCS to the precise quarter point. Use the guide drawings below.

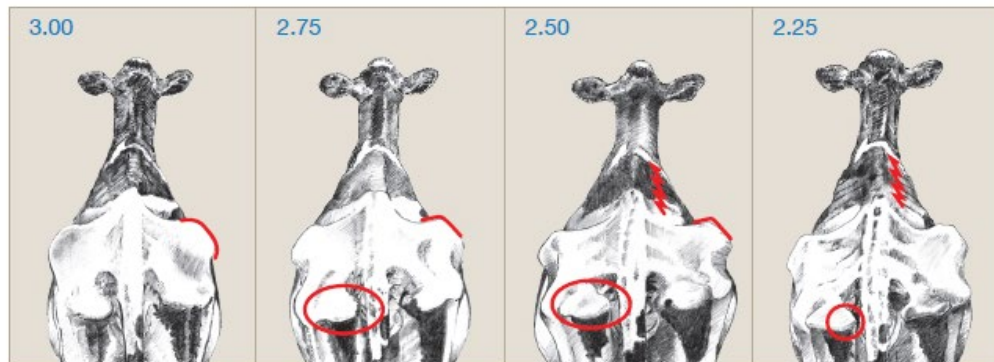


≥ 3.25: Flattened U



> 4.00: Straight line

Turn this page over for more information.



3.00

Hooks rounded

2.75

Hooks angular  
More prominent padding on pins

2.50

Pins and hooks angular  
Fat pad slightly palpable on point of pins

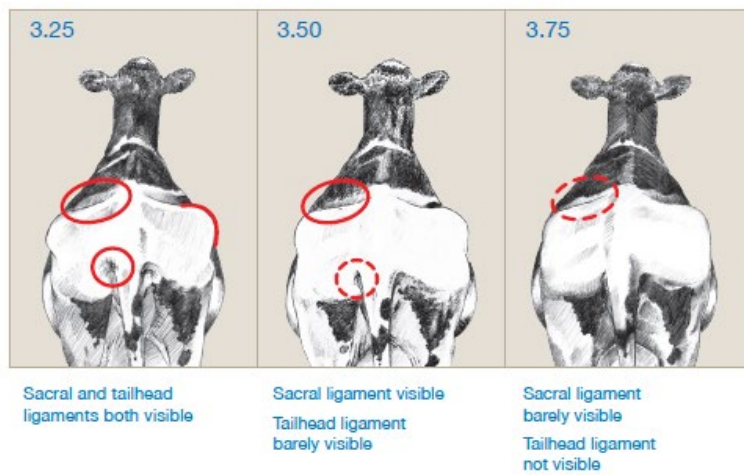
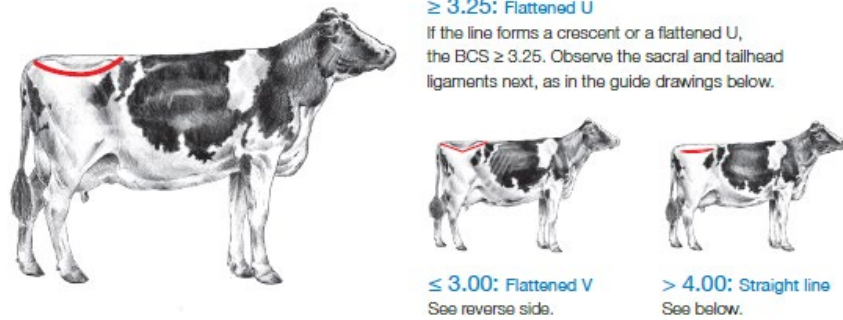
2.25

No fat pad on pins  
Visible corrugations halfway between tip and spine of short ribs

2.00: Corrugations visible three-fourths of the way from tip to spine

< 2.00: Thurl prominent  
Saw-toothed spine





## 9.4 Example of a written data entry sheet

The relationship of intrapelvic area and external morphimetry in cattle

(FYP.2016/FPV.71)

Location

En. Razlan, Lencayang

Breed

Fransiscan x

Cattle ID	Age (months)	BCS (out of 5)	Body weight (kg)	Thoracic circumference (cm)	Abdominal circumference (cm)	Distance between tuber coxae (cm)	Distance between tuber ischae (cm)	Pelvimetry	
								Vertical distance (cm)	Horizontal distance (cm)
9247	36	3.25	500.0	183.6	185.9	49.0	34.5	17.5	18
			504.0	183.9	186.0	49.0	34.6	17.25	18
			496.0	183.2	186.8	49.7	34.5	17.5	18
MS 08818	84	3.5	530.0	187.1	193.4	45.0	28.6	17.5	18.25
			535.0	187.4	193.8	45.0	28.5	17.5	18.25
			516.0	185.5	192.8	45.2	28.3	17	18
00 437	54	3.75	516.0	185.5	200.5	50	33	17.25	18
			512.0	185.0	200.5	49.5	32	18	18.25
			512.0	185.2	200.6	49.8	32	18.25	18
NS 80859	60	3.5	475.0	180.0	210.5	47.5	34.5	19	17.5
			475.0	179.9	211.5	47.4	34.6	19	17.5
			516.0	180.5	211.4	47.8	35	19	17.75
84	60	3	420.0	172.7	177.9	44.7	30.3	17.5	17
			414.0	172.3	177.1	44.7	30.6	17.5	17
			414.0	172.3	177.2	45	30.6	18	16.75
000 10	42	2.5	423.0	173.5	198.0	46.5	32.2	17.5	16
			432.0	174.7	197.3	49	32.8	17.5	16.25
			452.0	177.4	197.2	50	33.4	17.5	16
NS 82040	42	2.75	470.0	179.4	199.7	47.5	33.4	17.75	18
			470.0	179.5	198.5	47.8	33.2	18	18
			470.0	179.6	199.0	48.0	33.0	18	18
NS 82037	54	3	426.0	173.8	209.2	48.7	36.1	19	19
			426.0	174.1	209.1	48.6	36.2	19.5	19
			429.0	174.4	209.9	48.6	36.4	19.5	19.25
0887	30	2.75	370.0	165.8	179.4	46.8	29.8	14	14
			367.0	165.6	180.0	46.6	29.8	14.25	14
			370.0	165.9	179.7	46.6	29.7	14	14.5
6841	42	2.75	414.0	172.0	171.4	47	31.4	14.5	15.5
			414.0	172.3	171.8	46.9	31.3	14.75	16
			414.0	172.3	171.8	47.1	31.2	14.75	16
NS 82038	48	3.0	432.0	174.8	174.9	47.4	31.5	18	17
			432.0	175.1	175.1	47.7	31.8	18	16.75
			432.0	174.7	174.9	47.1	32.0	18	17.25
C1	48	2.75	564.0	190.5	185.3	55.3	38.0	15.5	17.75
			564.0	190.6	184.7	55.5	37.8	17	17.5
			555.5	187.4	183.8	55.6	38.0	17.5	17.5
BN 2894	24	2.75	384.0	167.8	193.9	47.1	33.1	17	17.25
			384.0	167.9	193.4	46.9	33.9	17	17
			389.0	168.1	193.7	46.8	33.6	17.25	16.75
BN 3638	30	3	320.0	157.9	179.1	44.0	34.0	14.75	14.25
			320.0	157.7	178.6	43.9	33.8	15	14.25
			317.0	157.5	178.9	43.9	33.8	15.25	14