Classification and regression tree analysis to predict calving ease in Sussex heifers using pelvic area dimensions and morphological traits

Article · March 2021

DOI: 10.5455/javar.2021.h499

Lubabalo Bila
Potchefstroom College of Agriculture

Thobela Louis Tyasi
University of Limpopo

Aphiwe Katikati
Central University of Technology

JOURNAL OF ADVANCED VETERINARY AND ANIMAL RESEARCH
ISSN 2311-7710 (Electronic)
http://doi.org/10.5455/javar.2021.h499
A periodical of the Network for the Veterinarians of Bangladesh (BDvetNET)

March 2021
VOL 8, NO. 1, PAGES 164–172

ORIGINAL ARTICLE

Classification and regression tree analysis to predict calving ease in Sussex heifers using pelvic area dimensions and morphological traits

Lubabalo Bila[1,2], Thobela Louis Tyasi[3], Pieter Fourie[1], Aphiwe Katikati[1]
[1]Faculty of Health and Environmental Sciences, Central University of Technology, Bloemfontein, South Africa
[2]Potchefstroom College of Agriculture, Department of Animal Production, Potchefstroom, South Africa
[3]School of Agricultural and Environmental Sciences, Department of Agricultural Economics and Animal Production, University of Limpopo, Sovenga, South Africa

ABSTRACT

Objectives: The objective of this study was to assess the relationship between pelvic measurements, namely pelvic height (PH), pelvic area (PA), and pelvic width, and linear body measurement traits, such as hindquarters width, rump length (RL), hip height (HH), body weight (BW), shoulder height, chest depth (CD), body length, and also calve birth weight (CBW) under different calving ease scores, namely no assistance, gently pull, and hard pull.
Material and Methods: A total of 51 first calf Sussex heifers at 24 months old, weighing approximately 440 ± 40.26 kg, were used for this study. Two-year-old bulls (n = 2), weighing approximately 800 kg, were used for mating the 51 heifers with a bull to cow ratio of 1:30 and 1:21. The fertility of bulls was assessed by a private veterinarian before the mating season. Calving ease was scored as follows: 1 = no assistance during parturition (normal), 2 = heifer assistance as gently pull, 3 = heifer assistance as hard pull, 4 = heifer cannot calf, 5 = heifer calved a dead calf, and 6 = heifer calf with the abnormal position.
Results: Descriptive statistics indicated that PH ($p < 0.01$) and RL ($p < 0.05$) were positively remarkable and different among calving ease scores. Correlation results of the no assistance Sussex heifers group revealed that CBW was positively correlated ($p < 0.05$) with PH. Classification and regression tree CART results demonstrated that PH, BW, CD, and HH play an important role in predicting calving ease in Sussex heifers.
Conclusion: The findings suggest that there is an association among PAs and biometric traits. The present study might help farmers select animals with higher PH, BW, CD, and HH during breeding to lower dystocia incidents during parturition. However, further studies need to be carried out in CART modeling to reduce dystocia in a larger sample size of Sussex heifers or other cattle breeds.

ARTICLE HISTORY
Received May 30, 2020
Revised September 01, 2020
Accepted September 05, 2020
Published March 10, 2021

KEYWORDS
Calving ease; Correlation; Hip height; Pelvic height; Sussex heifers

Introduction

Dystocia (birth difficulty) in cows leads to various hostile consequences for the dam and its progeny [1]. These include increased calf morbidity and mortality, decreased fertility and milk production, low cow survival, health welfare, and economic losses [2,3]. Fetomaternal disproportion is the key cause of dystocia in heifers [4], and efforts to inhibit it have focused mainly on dropping the calf's birth weight and ensuring adequate breeding birth weight. Calf birth weight and pelvis area contribute 33% and 12%, respectively, toward dystocia in heifers [4]. Breed effect on the incidence of dystocia is attributed to differences in the relative birth weight, pelvic structure, and large variations in pelvis dimensions in some breeds [4,5].

The classification and regression tree (CART) examination is a great arithmetical procedure that examines the most imperative traits in a specific data set and aids in designing a model [6]. CART is an arithmetical procedure that is appropriate in different forms of data, including continuous, ordinal, and nominal variables [7,6]. CART

Correspondence Lubabalo Bila bilalubabalo94@gmail.com Faculty of Health and Environmental Sciences, Central University of Technology, Bloemfontein, South Africa.

How to cite: Bila L, Tyasi TL, Fourie P, Katikati A. Classification and regression tree analysis to predict calving ease in Sussex heifers using pelvic area dimensions and morphological traits. J Adv Vet Anim Res 2021; 8(1):164–172.

predictions can be used as an aid to a farmer in the decision-making process regarding herd management [8]. CART might be used by dairy cattle farmers as a classification model to predict the class of dystocia [1]. Zaborski et al. [9] indicated that data mining algorithms are useful for discovering dystocia in Polish Holstein Friesian black and white cattle.

However, to the best of our knowledge, using CART to predict dystocia by biometric parameters in South African Sussex heifers has not yet been reported in the literature. Thus, the objectives of this paper are (1) to assess the association among pelvic measurements, namely pelvic width (PW), pelvic height (PH), and pelvic area (PA), and linear body measurement traits, such as body weight (BW), shoulder height (SH), chest depth (CD), hindquarters width (HW), rump length (RL), hip height (HH), body length (BL), and also calve birth weight (CBW) under different calving ease scores, namely no assistance, gently pull, and hard pull; (2) to develop a prototype for predicting calving ease from biometric parameters using the CART data mining algorithm. This research aims to assist Sussex cattle farmers in selecting the linear body measurement traits that might be useful during breeding to improve animal health welfare and reduce dystocia incidents during parturition.

Materials and Methods

Study area

This research project was conducted at Huntersvlei, also known as Rhys Evans Group farm (RE) in the Free State province, South Africa. The farm is located in Viljoenskroon, Fezile Dabi municipality; the site, temperatures, latitudes, longitude, and rainfall of the study area similar as described by Moeletsi [10].

Experimental animals and management

A total of 51 first calf Sussex heifers at 24 months old, weighing approximately 440 ± 40.26 kg, were used for this study. All heifers used for the study had a relatively good body condition score with an average of three and weighed more than 65% of the mature female BW of the Sussex breed. Two-year-old bulls (n = 2), weighing approximately 800 kg, were used for breeding the 51 heifers during the trial with a bull to cow ratio of 1:30 and 1:21. The fertility of bulls was assessed by a private veterinarian before the breeding season. The data collection measures were directed as described previously [11].

Fertility tests included a physical examination, measuring the scrotal circumference, and evaluation of semen quality. Bulls were tested 6 weeks before the breeding season. Physical inspection assessed whether a bull is in a position to see, smell, eat, and move normally. Physical inspection included scrutinizing the bull's eyes, teeth, feet, legs, and nutritional level. Possible disease or injury that affects joints, muscles, nerves, bones, or tendons may cause a bull to be structurally unsound. Furthermore, diseases or injuries to the penis or prepuce were examined to lower the inability of bulls to breed by natural mating. Scrotal circumference was measured by placing a measuring tape around the scrotum at the widest point; measurement is an indirect estimate of the mass of testicular tissue, which is directly related to sperm quantity and quality.

Semen was collected from the bulls using an electroejaculator. The seed quality was defined by the capacity of the ejaculate, motility, and morphology of the sperm cells immediately after collecting semen from the bull. This is calculated by placing a drop of semen on a microscope slide and observing the number of spermatozoa with forwarding movement in relation to those with other than forward movement. Sperm morphology was calculated by evaluating the number of normal spermatozoa in a sample ejaculate in relation to sperm with primary and secondary abnormalities [11]. Animals were managed extensively on natural pastures during the period of research, receiving production lick supplements to maintain their BW. To exclude the camp effect, the heifers were rotated every 2 weeks among the eight camps during the study. The pelvises of heifers were measured once prior breeding, using a technique adapted from Van Rooyen et al. [12] and Walker et al. [13]. The following formula was used to calculate the PA:

$$PA = \pi(PH/2 \times PW/2)$$ [12,14].

The PA dimensions were collected by the same person to avoid individual differences in accuracy in the measurements before breeding, where the measurements were collected once per heifer. The general procedure in taking pelvic measurements was to restrain the heifer in a chute using a light squeeze. A comfortable, normal standing position is best for this procedure. Feces was removed from the rectum, and the instrument caliper-type pelvimeter (Rice pelvimeter; Manufactured, Studbook Bloemfontein) was carefully placed into the rectum according to the procedure of Deutscher et al. [15] and Van Zyl [16]. After inserting the pelvimeter into the PA of the heifer, it was gradually opened by applying light pressure on the handle. The pelvimeter was then twisted from left to right to feel the ossified joint on the pubic symphysis as a reference point to measure the height between the dorsa pubic tubercle on the floor of the pelvis and the sacrum (spinal column) at the top.

The pelvimeter was then turned 90° sideways to measure the width of the pelvis at the widest points between the right and left shafts of the ilium bones. This is the horizontal diameter of the pelvis [17–19]. After that, the pelvimeter was carefully pulled out in the same twisted position to measure the width between the left tuber ischii and the right tuber ischii. The pelvimeter was removed from the heifer. The pelvimeter, after being used on each heifer, was then carefully washed with water, disinfected with a blend of gel and disinfectant [20,16].

Altogether, the measurements were taken in centimeters (cm).

Live weight (LW), HH, CD, shoulder width, hindquarter width (HW), birth weight (BW), BL, sex of the calf, and RL were measured in the study. Moreover, heifers were judged visually for body conformation (BC) and selection type (S), as described by the Sussex breed Standards of Excellence on a scale of 1–5. All the parameters were measured according to the method described by Fourie et al. [21].

Briefly, LW (kg) was measured following a 12-h fasting period. SH (cm) was measured vertically from the thoracic vertebrae to the ground; CD was measured from the spianus to the xiphoid process of the sternum; the hindquarter width (cm) was measured between the left thurl to the right thurl; rump length (cm) was measured as the distance from the tuber coxae to the pin bone; hip height (cm) was measured as the distance from the ground just in front of the hind hoofs over the hook (hip); birth weight of the calve (kg) and sex of the calf were also recorded.

During the parturition process, the calving ease score codes were used to score each heifer that calved, as explained by Fourie et al. [21]. Calving ease was scored as follows: 1 = no assistance during parturition (normal), 2 = heifer assistance as gently pull, 3 = heifer assistance as hard pull, 4 = heifer cannot calf, 5 = heifer calved a dead calf, and 6 = heifer calf with the abnormal position.

Statistical analysis

Data were analyzed by the statistical analysis system [22] for descriptive statistics, and NCSS statistical analysis software [23] was used for computing the correlation matrix between variables and constructing heat map of correlation coefficients. Statistical Package for the Social Sciences [24] software was used for computing CART data mining algorithm.

Results

Descriptive statistics

Boxplots (Fig. 1) show the summary of CBW distribution on different calving ease scores of Sussex heifers. The findings indicated that there was a higher significant difference at $p < 0.01$ probability level across calving ease scores.

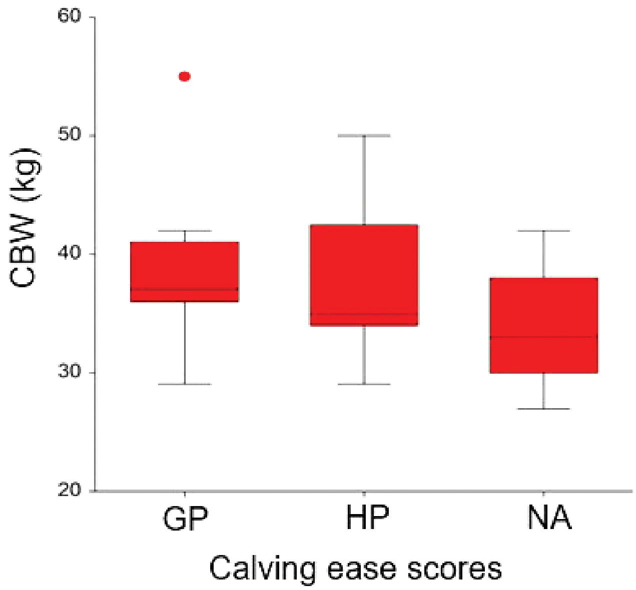

Figure 1. Boxplots displaying median, minimum, maximum, 25th percentile, and 75th percentile values of Sussex calf birth weight. CBW: calve birth weight, GP: gently pull, HP: hard pull, and NA: no assistance.

Boxplots (Fig. 2) show the summary of pelvic measurements distribution on different calving ease scores of Sussex heifers. The results indicated that there was a significant difference at $p < 0.01$ probability level across calving ease scores. Figure 2A shows that no assistance score had a higher PH than gently pull and hard pull scores. In the boxplots (Fig. 2B), PW of the no assistance score showed a minimum value of less than 14 cm, median of greater than 16 cm, and a maximum of less than 17 cm, respectively. In the boxplots (Fig. 2C), PA of the no assistance score showed minimum values of less than 200 cm^2, median of greater than 220 cm^2, and a maximum of less than 260 cm^2, respectively.

Boxplots (Fig. 3) show linear body measurements' distribution on different calving ease scores of Sussex heifers. The findings indicated that there was a remarkable difference at $p < 0.01$ probability level across calving ease scores. In the boxplots (Fig. 3A), BL of the no assistance score showed a minimum value of less than 140 cm, median of greater than 150 cm, and a maximum value of greater than 160 cm, respectively. In the boxplots (Fig. 3B), BW of the no assistance score showed a minimum value of less than 350 kg, median of greater than 400 kg, and a maximum of greater than 500 kg, respectively. In the boxplots (Fig. 3C), HH of the no assistance score showed a minimum value of less than 120 cm, median of greater than 125 cm, and a maximum of greater than 135 cm, respectively. In the boxplots (Fig. 3D), HW of the no

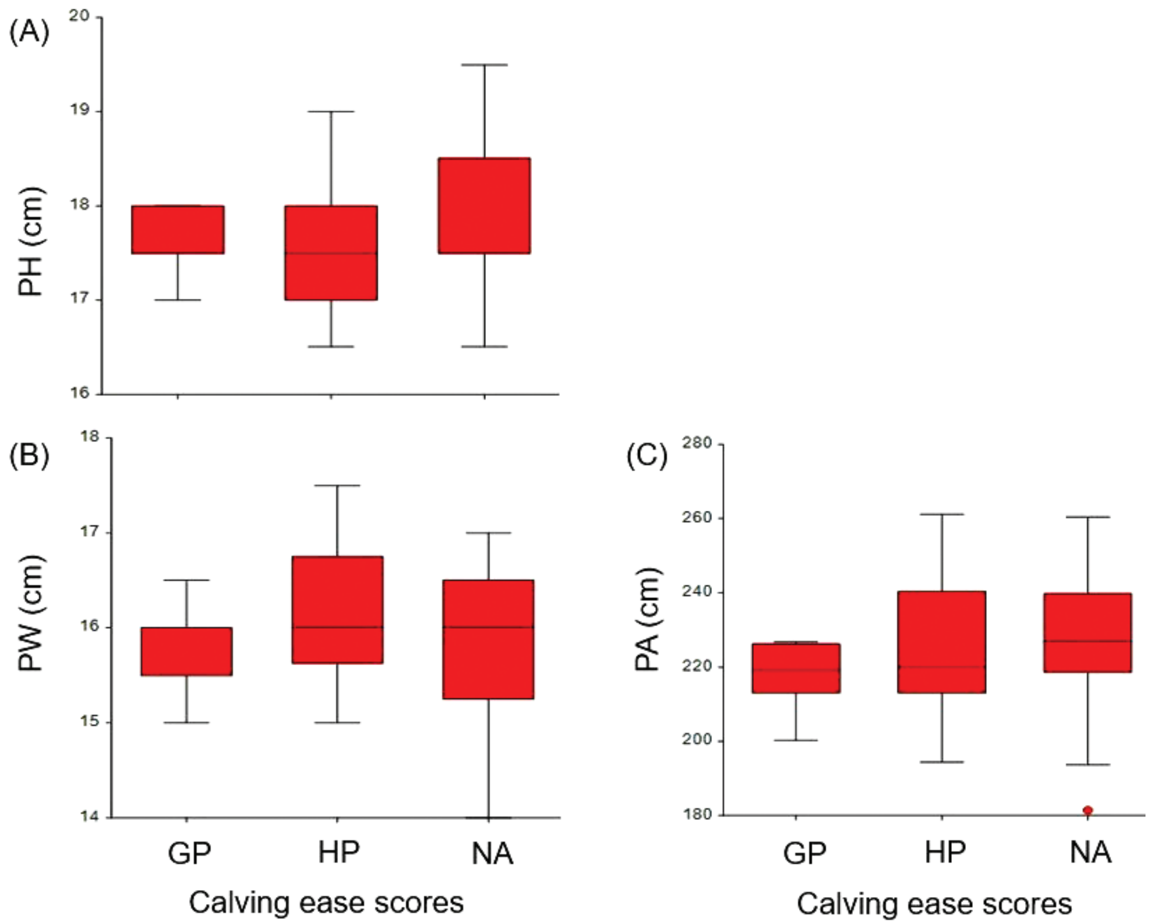

Figure 2. Boxplots displaying median, minimum, maximum, 25th percentile, and 75th percentile values of Sussex heifer's pelvic measurements. (A) PH = Pelvic height, (B) PW = Pelvic width, and (C) PA = Pelvic area. GP = gently pull, HP = hard pull, and NA = no assistance.

assistance score showed a minimum value of less than 120 cm, median of greater than 125 cm, and a maximum value of greater than 135 cm, respectively. In the boxplots (Fig. 3E), RL of the no assistance score showed a minimum value of less than 115 cm, median of greater than 125 cm, and the maximum value of greater than 130 cm, respectively. In the boxplots (Fig. 3F), CD of the no assistance score showed a minimum value of less than 60 cm, median of less than 70 cm, and a maximum of greater than 70 cm, respectively. In the boxplots (Fig. 3G), SH of the no assistance score showed a minimum value of less than 120 cm, median of greater than 125 cm, and a maximum of greater than 135 cm, respectively.

Descriptive statistics (Table 1) of measured traits showed that the PH among calving ease scores was significantly different ($p < 0.05$) with higher mean numerical values in no assistance than gently pull and lastly hard pull score (18.21 ± 0.13, 17.63 ± 0.11, and 17.57 ± 0.29, respectively). The coefficient of variation (CV) was calculated by dividing the mean with the standard deviation (Std. Dev), and the results showed a range from 0.91 to 12.40 in no assistance, from 2.22 to 17.85 in gently pull, and from 4.47 to 18.11 in hard pull scores.

Correlations

The phenotypic correlation of measured traits of the no assistance Sussex heifers group is shown in Figure 4. Correlation findings showed that BW had a highly positive significant ($p < 0.01$) correlation with PA, while had a positive remarkable ($p < 0.05$) correlation with CBW, PH, and PW. Our results further show that CBW had a high positive significant correlation with PH and low positive significant correlation with HW, HH, RL, PW, CD, and SH. The PA showed a high positive significant correlation with CD and SH.

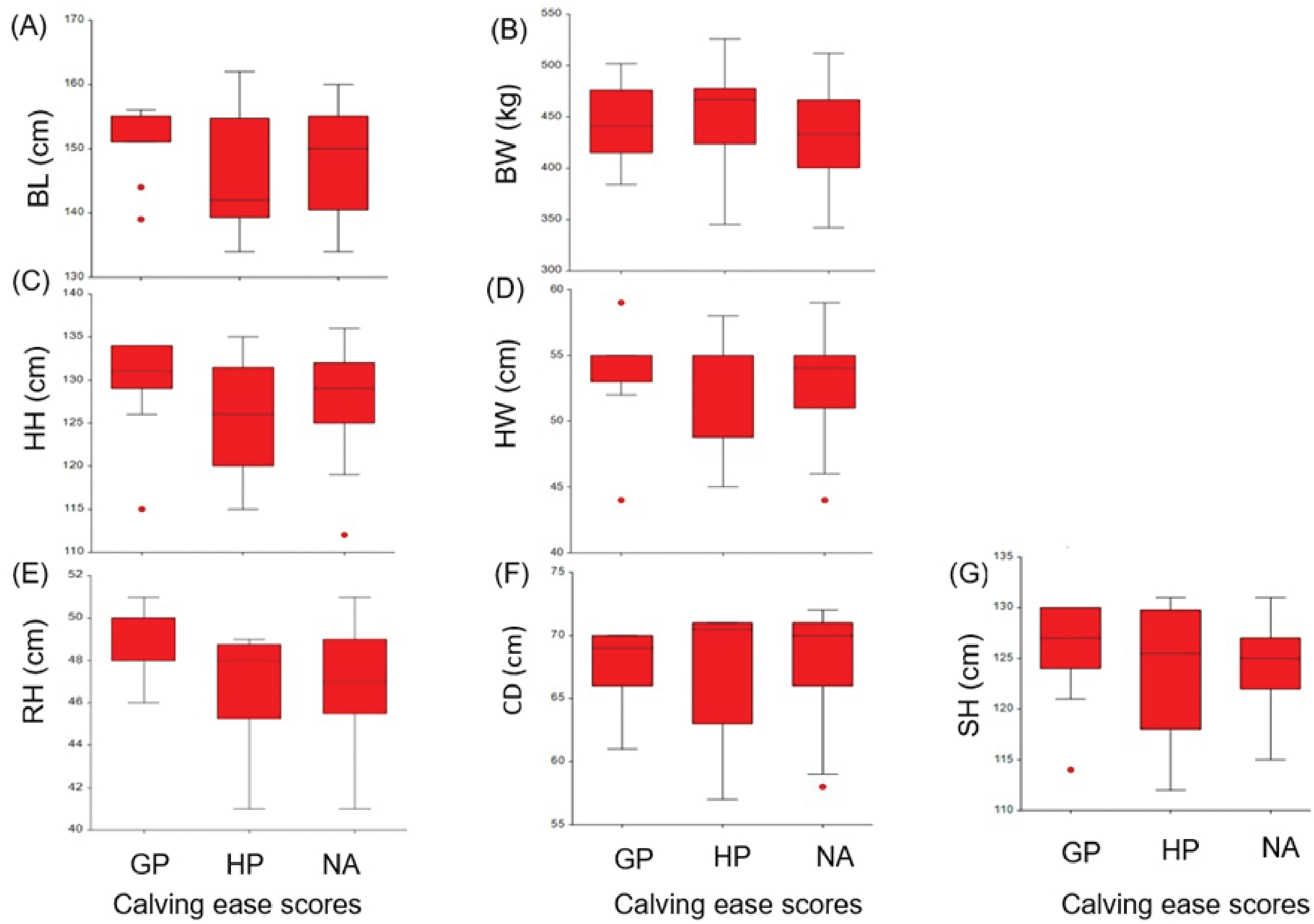

Figure 3. Boxplots displaying median, minimum, maximum, 25th percentile, and 75th percentile values of Sussex heifer's linear body measurements. (A) BL = Body length, (B) BW = Body weight, (C) HH = Hip height, (D) HW = Hindquarters width, (E) RL = Rump length, (F) CD = Chest depth, and (G) SH = shoulder height. GP = gently pull, HP = hard pull, and NA = no assistance.

Phenotypic correlation of measured traits of gently pull Sussex heifers group are shown in Figure 5. Pearson's correlation findings revealed that BL had a high negative remarkable correlation with BW and a low positive correlation with CD, CBW, and PH. CBW of gently pull Sussex heifers group revealed a positive significant correlation with PH, HH, SH, and HW.

Phenotypic correlation of measured traits of hard pull Sussex heifers group is shown in Figure 6. Pearson's correlation findings showed that most of the measured linear body measurement traits for hard pull assistance Sussex heifers group are highly positive and significantly correlated ($p < 0.01$).

CART method

CART was used for modeling calving ease from biometric parameters in the Sussex heifer cattle breed (Std. Dev, n: number, Mean: average).

The CART model was used in calving ease from linear body measurement in Sussex heifers (Fig. 7), with the calving ease as a dependent variable and linear body measurement traits as the independent variables. This model contained a total of eight nodes. Node 0 is the root node containing the descriptive statistics of calving ease (mean = 1.490, Std. Dev = 0.07, and n = 51). Node 0 on the basis of PH was divided into node 1 (≤ 18.25 cm) and node 2 (> 18.25 cm), respectively. Node 1 was divided on the basis of the dam's BW into node 3 (≤ 140.50 kg) and node 4 (> 410.50 kg). Node 4 was divided on the basis of CD into node 5 (≤ 60.00 kg) and node 6 (> 60.00 kg). The final node to be divided in this model was node 6, which was divided on the basis of hip height into node 7 (≤ 130.50 kg) and node 8 (> 130.50 kg), respectively. In all the terminal nodes, node 7 appeared to be the best node as it recorded the highest predicted mean (2.444 cm) than node 2 (mean = 1.100 cm), node 3 (mean = 1.278 cm), node 5 (mean =

Table 1. Descriptive statistics of measured traits.

Traits	Calving ease scores						Sign
	No assistance		Gently pull		Hard pull		
	Mean ± SEM	CV	Mean ± SEM	CV	Mean ± SEM	CV	
CBW (kg)	33.86 ± 0.73	12.40	38.31 ± 2.06	17.85	37.92 ± 2.59	18.11	
Body measurements							
BW (kg)	434.24 ± 6.77[a]	8.95	439.90 ± 10.44[a]	7.87	447.71 ± 21.55[a]	12.73	0.71
HH (cm)	128.00 ± 0.91[a]	4.12	129.45 ± 1.63[a]	4.19	125.71 ± 2.72[a]	5.73	0.39
CD (cm)	67.51 ± 0.74[a]	0.91	67.36 ± 1.02[a]	5.06	67.14 ± 2.16[a]	8.53	0.97
SH (cm)	124.57 ± 0.67[a]	3.12	125.45 ± 1.42[a]	3.75	122.85 ± 2.47[a]	5.32	0.46
HW (cm)	52.93 ± 0.63[a]	6.89	53.27 ± 1.08[a]	6.77	52.71 ± 1.80[a]	9.07	0.94
BL (cm)	148.96 ± 1.34[a]	5.20	151.72 ± 1.64[a]	3.58	146.57 ± 3.91[a]	7.06	0.37
RL (cm)	47.15 ± 0.41[ab]	5.03	49.00 ± 0.53[a]	3.65	46.57 ± 1.08[b]	6.18	0.05
Pelvic measurements							
PH (cm)	18.21 ± 0.13[a]	4.11	17.63 ± 0.11[ab]	2.22	17.57 ± 0.29[b]	4.47	0.01
PW (cm)	15.89 ± 0.14[a]	5.08	15.68 ± 0.13[a]	2.94	16.14 ± 0.32[a]	5.27	0.45
PA (cm)	227.52 ± 3.01[a]	7.62	217.21 ± 2.39[a]	3.65	223.19 ± 8.13[a]	9.64	0.20

SEM = standard error of mean; CV = coefficient of variation; CBW = calve birth weight; BW = body weight; HH = hip height; CD = chest depth; SH = shoulder height; HW = hindquarters width; BL = body length; RL = rump length; PH = pelvic height; PW = pelvic width; PA = pelvic area; Sign = significance.

Std. Dev = standard deviation; n = number, Mean: average.

[abc]Means denoted by different alphabets across rows differ ($p < 0.05$) significantly.

*Significant difference ($p < 0.05$), ns = not significant ($p > 0.05$).

1.000 cm), and node 8 (mean = 1.778 cm), respectively. The developed model displayed that node 6 had the lowest variance [(0.000)2 = 0.000] and the variance of the root node or dependent variable (calving ease) was S2y = (0.731)2 = 0.534. The unexplained variation in the calving ease was S2e = risk value ÷ S2y = 0.270 ÷ 0.534 = 0.506 and the variation in the model was explained as S2y = 1 – S2e = 1 – 0.506 = 0.494, respectively.

Discussion

The availability of computer packages for data evaluation in the field of animal breeding contributes to the swift growth in the use of CART model as a data mining algorithm technique [6]. The summary of the current study demonstrates that Sussex heifers for the no assistance group on calf birth weight had lower numerical values on descriptive statistics. This study firstly investigated the relationship between PA measurements, such PH, PW, and PA, with linear body measurements traits, such as CBW, BW, HH, CD, SH, HW, BL and RL, using Pearson's correlation in three calving ease scores, namely no assistance, gently pull, and hard pull assistance. Our correlation findings demonstrated that certain linear body measurements, such as BW and RL, had a negative correlation with PA measurements. Therefore, improving BW and RL might result in high chances of a heifer experiencing dystocia. Thus, BW and RL might be well incorporated in the selection criteria during breeding to lower the chances of heifers experiencing birth difficulty. Our results are in line with the study of Holm et al. [4], which suggests that the PA might be used to manage dystocia in

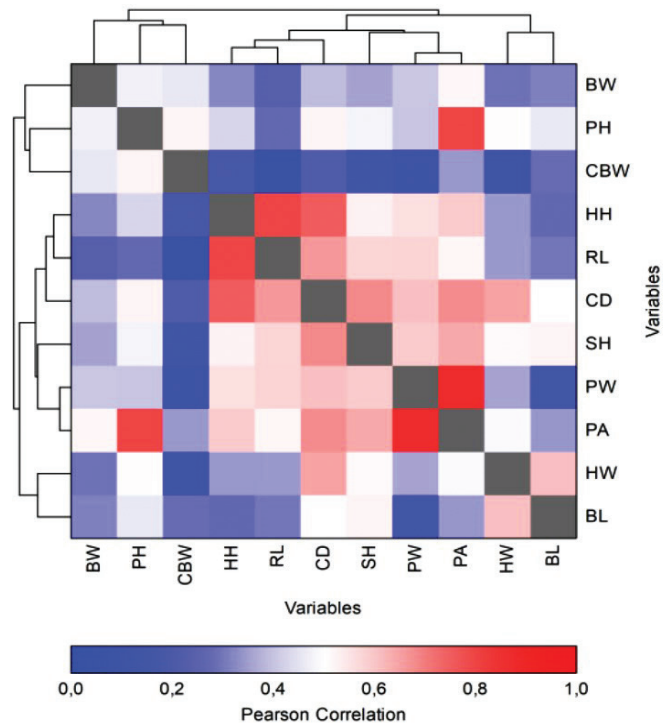

Figure 4. Heat map of the phenotypic correlation of measured traits of the no assistance Sussex heifer group. Correlation color demonstration is as follows: high correlation is red, mid correlation is white, and low correlation is blue. BW = body weight; CBW = calve birth weight; HH = hip height; RL = rump length; CD = chest depth; SH = shoulder height; PW = pelvic width; PA = pelvic area; HW = hindquarters width; BL = body length. Correlation was tested at $p < 0.05$ for significance and $p < 0.01$ for high significance.

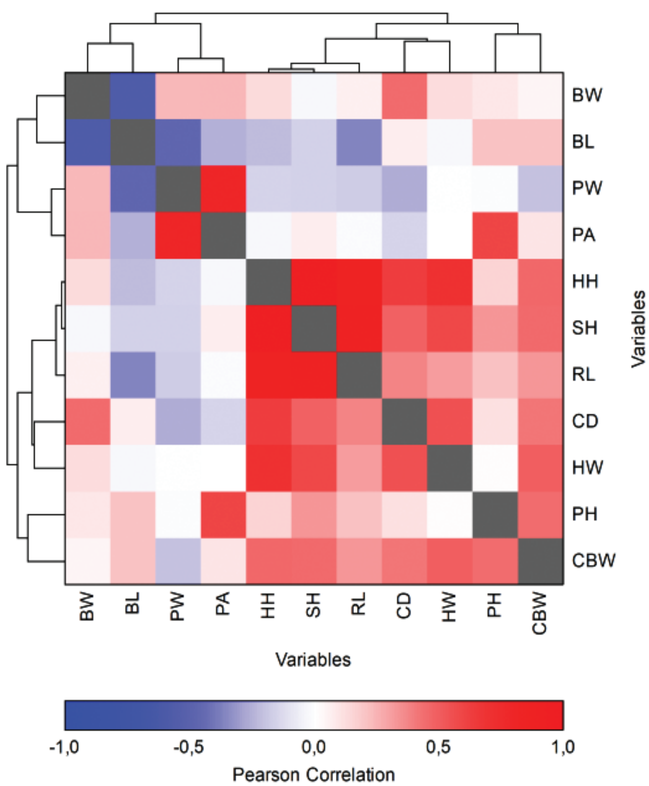

Figure 5. Heat map of the phenotypic correlation of measured traits of the gently pulled assistance Sussex heifer group. Correlation color demonstration is as follows: high correlation is red, mid correlation is white, and low correlation is blue. BW = body weight; CBW = calve birth weight; HH = hip height; RL = rump length; CD = chest depth; SH = shoulder height; PW = pelvic width; PA = pelvic area; HW = hindquarters width; BL = body length. Correlation was tested at $p < 0.05$ for significance and $p < 0.01$ for high significance.

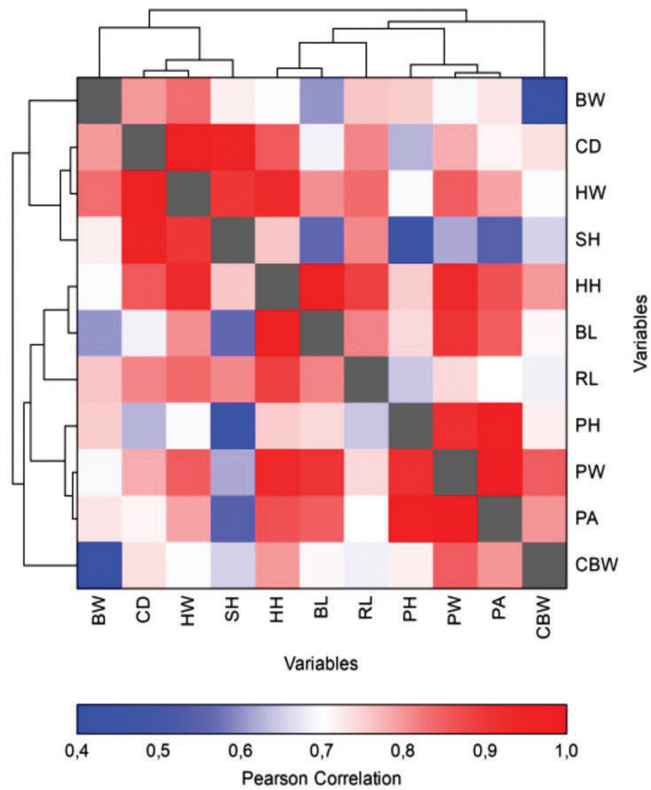

Figure 6. Heat map of the phenotypic correlation of measured traits of the hard pulled assistance Sussex heifer group. Correlation color demonstration is as follows: high correlation is red, mid correlation is white, and low correlation is blue. BW = body weight; CBW = calve birth weight; HH = hip height; RL = rump length; CD = chest depth; SH = shoulder height, PW = pelvic width; PA = pelvic area; HW = hindquarters width; BL = body length. Correlation was tested at $p < 0.05$ for significance and $p < 0.01$ for high significance.

heifers. However, Tyasi et al. [6] demonstrated that phenotypic correlation coefficient only aids to specify the magnitude associations without discovering the cause of the association between the measured traits. Hence, we employed the CART model to examine the most important body measurement traits playing a significant role in calving ease of Sussex heifers. CART results indicated that PH, BW, CD, and HH play a critical role in calving ease. Therefore, PH, BW, CD, and HH might be well incorporated in the selection criteria during breeding to drop incidents of heifers to experience dystocia. These results suggest that PAs and biometric traits of Sussex heifers need to be improved genetically since they are the indicators of calving ease. CART prototype established from the current study displayed that PH had the highest significant role in calving ease, followed by BW, respectively. These results suggest that PH and dam's BW might have a physiological effect of calving ease. Calving ease is a complex reproductive trait of economic importance in cattle [25].

Hence, several researchers focused on a different aspect of calving ease. Nugent et al. [26] indicated that calving ease has a strong relationship with linear body measurement traits of new-born calves. Anderson [27] revealed that many factors influence the incidence of dystocia in cattle, including dam age, dam's PA, calf birth weight, calf sex, dam size, gestation length, sire breed, dam breed, shape of calf, and position of the uterus. Eaglen et al. [28] suggest that calving ease has a phenotypic influence on the fertility and milk production of the dam and calf. Physiological effects of calving ease require more attention to reduce the incidence of dystocia.

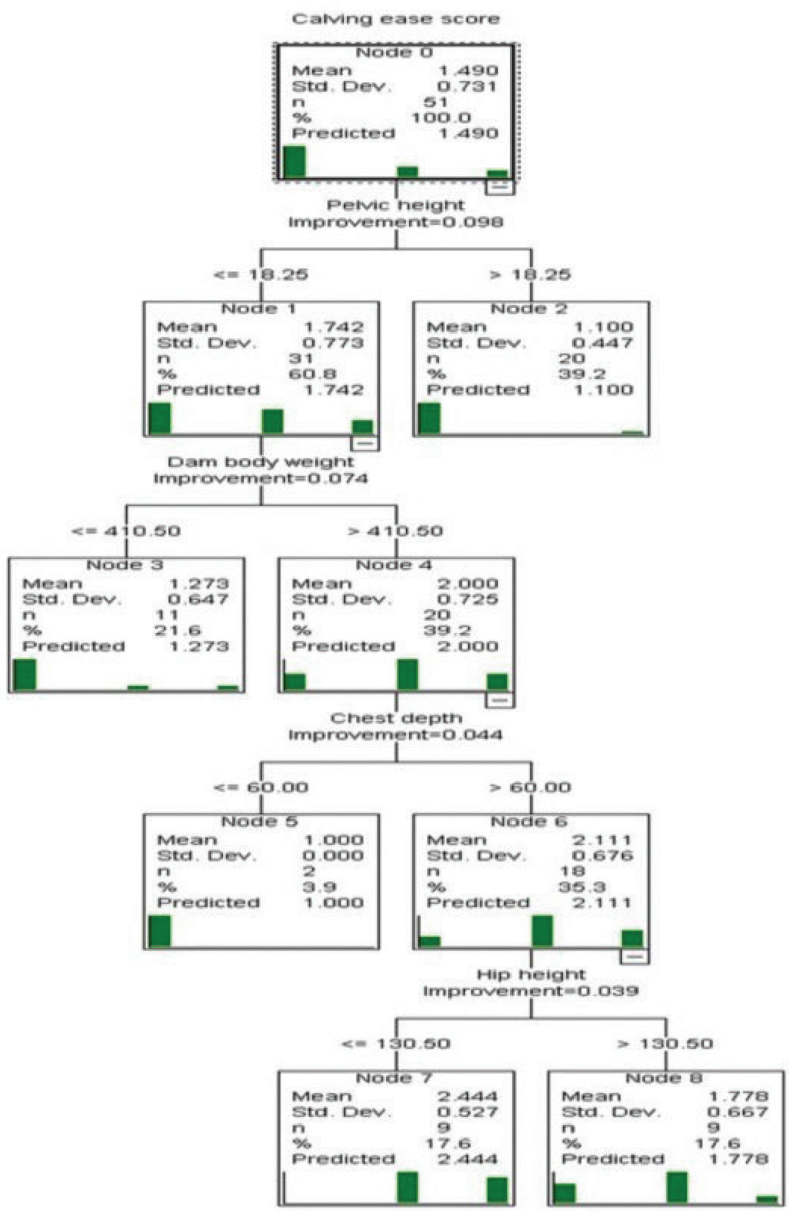

Figure 7. Demonstration of the CART modeling of calving ease from biometric traits in Sussex heifer cattle breed.

Conclusion

Correlation was used to examine the association among PAs and biometric traits. Interestingly, the results show that there is a relationship between PAs and biometric traits. These findings suggest that linear body measurement traits might be used to improve the PA measurement traits of Sussex heifers. The CART model was used to determine the important traits that influence calving ease in Sussex heifers. CART results indicated that that PH, dam's BW, CD, and hip height had a significant role in calving ease of Sussex heifers. Farmers might use the established CART model to reduce the incidence of birth difficulty in heifers. The findings of the study might help Sussex cattle farmers during breeding to lower incidents of dystocia since it indicated that biometric traits exhibit a substantial role in calving ease. Further studies need to be carried out in CART modeling with the focal intention to drop dystocia in a larger sample size of Sussex heifer or other cattle breeds.

List of Abbreviations

Pelvic height (PH), pelvic area (PA), PW, shoulder height (SH), chest depth (CD), BW, hindquarters width (HW), hip height (HH), body length (BL), rump length (RL), calve birth weight (CBW), classification and regression tree (CART), Rhys Evans group farm (RE), centimeters (cm), BC, selection type (S), kilograms (kg), not significant (ns), standard error of the mean (SEM), coefficient of variation (CV), significance (Sign), standard deviation (Std. Dev), number (n), average (mean), National Council for the Social Studies (NCSS).

Acknowledgments

The authors convey their appreciation to the Central University of Technology, Free State, Potchefstroom College of Agriculture, AgriSETA, and the National Research Fund for funding the study. They also thank the RE and farm-workers for their endless support and for allowing to conduct this trial on their farm.

Authors' contribution

Lubabalo Bila designed the experiment and wrote the manuscript. Pieter Fourie designed and supervised the experiment. Thobela Louis Tyasi analyzed the data and wrote the manuscript. Aphiwe Katikati revised the manuscript. Thobela Louis Tyasi read, revised, and approved the final manuscript.

Conflict of interest

The authors declare that they have no conflict interests.

References

[1] Zaborski D, Proskura WS, Grzesiak W. Comparison between data mining methods to assess calving difficulty in cattle. Rev Colomb Cienc Pecu 2017; 30:196–208; https://doi.org/10.17533/udea.rccp.v30n3a03

[2] Abdela N, Ahmed WM. Risk factors and economic impact of dystocia in dairy cows: a systematic review. J Reprod Infertil 2016; 7:63–74.

[3] Mee JF, Berry DP, Cromie AR. Risk factors for calving assistance and dystocia in pasture based Holstein-Friesian heifers and cows in Ireland. Vet J 2011; 187:189–94; https://doi.org/10.1016/j.tvjl.2009.11.018

[4] Holm DE, Webb EC, Thoompson PN. A new application of pelvis area data as culling tool to aid in the management of dystocia in heifers. J Anim Sci 2014; 92:2296–303.

[5] Nogalski Z, Mordas W. Pelvic parameters in Holstein-Friesian and Jersey heifers in relation to their calving. Pak Vet J 2012; 32:507–10.

[6] Tyasi TL, Makgowo KM, Mokoena K, Rashijane LT, Mathapo MC, Danguru LW, et al. Classification and regression tree (crt) analysis to predict body weight of potchefstroom koekoek laying hens. Adv Anim Vet Sci 2020; 8(4):354–9; https://doi.org/10.17582/journal.aavs/2020/8.4.354.359

[7] Aytekin C, Ni X, Cricri F, Aksu E. Clustering and unsupervised anomaly detection with l2Normalized deep auto-encoder representations. International Joint Conference on Neural Networks (IJCNN), Rio de Janeiro, Brazil, pp 1–6, 2018; https://doi.org/10.1109/IJCNN.2018.8489068

[8] Zaborski D, Ali M, Eyduran E, Grzesiak W, Tariq MM, Abbas F, et al. Prediction of selected reproductive traits of indigenous Harnai sheep under the farm management system via various data mining algorithms. Pak J Zool 2019; 5(1):421–31.

[9] Zaborski D, Proskura WS, Grzesiak W. The use of data mining methods for dystocia detection in pPolish holstein-friesian black-and-white cattle. Asian-Australas J Anim Sci 2018; 31(11):1700–13; https://doi.org/10.5713/ajas.17.0780

[10] Moeletsi ME. Agroclimatological risk assessment of rain-fed maize production for the Free State Province of South Africa. Unpublished PhD thesis, Department of Soil, Crop and Climate Sciences, University of the Free State, Bloemfontein, South Africa, pp 89–91, 2010.

[11] Arangasamy A, Venkata Krishnaiah M, Manohar N, Selvaraju S, Pushpa Rani G, Soren NM, et al. Advancement of puberty and enhancement of seminal characteristics by supplementation of trace minerals to bucks. Theriogenology 2018; 110:182–91; https://doi.org/10.1016/j.theriogenology.2018.01.008

[12] Van Rooyen I, Fourie PJ, Schwalbach L. Relationship between pelvic and linear body measurements in Dorper ewes. S Afr J Anim Sci 2012; 42(5):498–502; https://doi.org/10.4314/sajas.v42i5.11

[13] Walker D, Ritchie H, Hawkins D. Pelvic measurements and calving difficulty in beef cattle. Michigan State University, Department of Animal Science: Charles Gibson Department of large animal clinical science, East Lansing, MI, 1992.

[14] Morrison D, Williamson W, Humes P. Estimates of heritabilities and correlations of traits associated with pelvic area in beef cattle. J Anim Sci 1986; 63(2):432–7; https://doi.org/10.2527/jas1986.632432x

[15] Deutscher G, Colburn D, Davis R. Climate affects birth weights and calving difficulty. Nebr Beef Cattle Rep 1999; MP-71.

[16] Van Zyl PL. Pelvic measurements and dimensions. (I. M. Van Rooyen, Interviewer), Heilbron, South Africa, 2008.

[17] Cloete S, Scholtz A, Ten Hoop JM, Lombard P, Franken M. Ease of birth relation to pelvic dimensions, litter weight and conformation of sheep. Small Rum Res 1998; 31:51–60; https://doi.org/10.1016/S0921-4488(98)00119-9

[18] Kilgour RJ, Haughey KG. Pelvic size in Merino ewes selected for lamb rearing ability is greater than that of unselected Merino ewes. J Anim Reprod Sci 1993; 31:237–42; https://doi.org/10.1016/0378-4320(93)90008-F

[19] Van Donkersgoed J, Ribble CS, Townsend HG, Janzen ED. The usefulness of pelvic area measurements as an on-farm test for predicting calving difficulty in beef heifers. Can Vet J 1990; 31:190–3.

[20] Patterson JP, Herring W. Pelvic measurements and calving difficulty in beef cattle. G2017. University Extension. University of Missouri, Columbia, MO, pp 1–3, 1997.

[21] Fourie PJ, Neser FW, Olivier JJ, Van der Westhuizen C. Relationship between production performance, visual appraisal and body measurements of young Dorper rams. S Afr J Anim Sci 2002; 4:256–62.

[22] SAS. User guide: statistics release 9.2. Statistical Analysis System Institute, Inc., Cary, NC, 2009.

[23] NCSS Statistical Software: Chapter 206, Two-sample t-test; Available via https://www.ncss.com/ (Accessed 13 February 2020)

[24] IBM SPSS. Statistical packages for social sciences for windows: base system user's guide, IBM statistics, 25. SPSS Inc., Chicago, IL, 2016; https://doi.org/10.2527/jas.2013-6967

[25] AAlam M, Dang CG, Choi TJ, Choy YH, Lee JG, Cho KH. Genetic parameters of calving ease using sire-maternal grandsire model in Korean Holsteins. Asian-Australas J Anim Sci 2017; 30(90):1225–33; https://doi.org/10.5713/ajas.16.0322

[26] Nugent RA, III, Notter DR, Beal WE. Body measurements of newborn calves and relationship of calf shape to sire breeding values for birth weight and calving ease. J Anim Sci 1991; 69(6):2413–21; https://doi.org/10.2527/1991.6962413x

[27] Anderson P. Minimizing calving difficulty in beef cattle. Asian-Australas J Anim Sci 2017; 30(9):1225–33; https://doi.org/10.5713/ajas.16.0322

[28] Eaglen SAE, Coffey MP, Woolliams JA, Mrode R, Wall E. Phenotypic effects of calving ease on the subsequent fertility and milk production of dam and calf in UK Holstein-Friesian heifers. J Dairy Sci 2011; 94:5413–23; https://doi.org/10.3168/jds.2010-4040