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Calf Birth Weight Prediction Accuracy Using Calf Parturition Durability and Metric Body Measurements in Ongole Crossbred Heifers

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Abstract
Normal parturition should be completed without human interference, leaving a healthy heifer with a viable calf to avoid serious economic losses due to their increasing mortality. Calf birth weight (CBW) was reported to be the most important factor influencing calving difficulty. Considering those problems, this study was undertaken to estimate CBW using linear body measurements of heifers mated by artificial insemination method. Study was involving 103 Ongole crossbred heifers at the artificial insemination center of North Sulawesi province, Indonesia. Data on heifer live weight (HLW), heifer body length (HBL), heifer chest girth (HCG), calf parturition durability (CPD) and CBW were collected from 103heifers at ages of two to three years old. To predict CBW, all linear body measurements as independent variables in multiple regression equation affecting dependent variable of CBW were included in the models using statistical datasheet of Microsoft Office Excel 2007. Results showed that multiple regressionmodel can be recommended to predict CBW of Ongole crossbred heifers using HCG, HBL and CPD as independent variables as follows: CBW (Y *in kg*) = 26.8862 + 0.00478 HBL (X_1 *in cm*)– 0.02703 HCG (X_2 *in cm*)+ 0.04741 CPD (X_3 *in minute*) with determination coefficient (R^2) of 0.93.

1. Introduction

Parturition of heifers was process of fetus delivery from the uterus of dam passing the normal pregnancy period of 275 to 285 days (Ratnawati et al., 2007). Delivery process of dam was an important parts of reproduction process started from either natural mating or artificial insemination, and pregnancy period and ended at fetus parturition process. These important stages of parturition process including durable parturition could be observed by breeders to define a normal parturition of pregnant heifers using shortly time without difficulty. Good reproductive cows were indicated by normal parturition process, leaving a healthy cow with a viable calf to avoid serious economic losses due to the increase mortality of both dam and calf.

Healthy cows and their calves after easy calving period affected rapid recovery development of both calves and cows facing the next reproduction stages including the next mating and pregnant seasons. In addition to animal factors, breeders should actively observe the characteristic signs of the animal parturition, mainly at the end of pregnant period. Breeders should also actively play role to assist parturition process of the pregnant cows. The characteristic signs of the cow parturition were indicated by restless sleeping, beat around the bush, high frequent defecation, existence of swell and mucus vulva. Normal parturition process of cow was divided into three stages of events including the widening of uterus base during period of two to six hours, the releasing fetus during period of half to one hour and the releasing placenta during period of four to five hours (Hafez and Hafez, 2000). Cows showing parturition process of more than eight hours from the first characteristic sign of parturition, indicated difficulty of calving delivery (dystocia) causing calf mortality(Meredith, 2000; Jackson, 2004). Calving difficulty incident in animal farm reached 3.3 percents from the total of animal population causing serious economic losses due to the increase mortality of both dam and calf (Manan, 2002).

Calving difficulty (dystocia complex) was the most important cause of calf death, with 50.9 percents of all death falling into this category (Bellows et al., 1987). Small body size of heifers was an impediment to normal parturition (Johnson et al., 1988). Calf birth weight was reported to be the most important factor influencing calving difficulty and there was little correlation between pelvic measurements and calving performance (Naazie et al., 1991; Van Donkersgoed et al., 1990).Beef Synthetic heifers had more difficult calving than Dairy Synthetic heifers (Naazie et al., 1991). Body weight and body size of cows would be considered as the important factors influencing the reproductive efficiency of the Indonesian native cows (Paputungan, 1997). The incidence and severity of calving difficulty in the first calving heifers could be significantly reduced by using sires with low birth weight which would result in calves with low birth weight (Paputungan, et al., 2000).

Most Ongole crossbred cattle in rural areas of Indonesia were owned by rural households and farmers. Often, the marketing of animals was based on visual assesment, while drugs were administrated mostly by estimation. Regularly, the right use of live weight criteria in feeding, marketing and drug administration required sophisticated facilities such as weighing scales (monitor digital electrical scale), which wasexpensive and not readily affordable by many rural households.Beef cattle production of local household farmers was difficult to be practically predicted due to limited availability of animal weighing scale machine on the field. The objective of this study was to estimate calf birth weight (CBW) using all linear body measurements of heifers mated by artificial insemination method in North Sulawesi province of Indonesia.

2. Materials and Methods

2.1. Location of Study and Experimental Animals

Animals used in this research were Ongole crossbredheifers with unknown composition of Ongole breed and Local Indonesian beef cattle in North Sulawesi province. All animals used in this study were unpregnant heifers at one to two weeks after parturition process, at the ages ranging from two to three and half years old. Animal breeding strategy of household farmers were mated with the artificial insemination technique by the inseminator using bull sperms collected from Ongole Bull Sperm Bank Institution, located in Singosari, East Java Province, Indonesia. Animal household farmers were located in two villages of Tumaratas and Tonsewer, Minahasa Regency, North Sulawesi Province. This regency is categorized as agricultural areas with altitude of 600-700 m above sea level. It is characterized by cool and humid climate of 25-28^{o}C and 70-80 percents, respectively.

The number of Ongole crossbred animals, randomly chosen in this study, were 103 grass-fedheifers. Age was primarily determined by dentition with the indication as follows: cows showed unchanged milk teeth, indicating the age of less than one year old; cows showed two changed milk teeth, indicating the age of one and half to two and half years old; cows showed four changed milk teeth, indicating the age of two and half to three and half years old; cows showed six changed milk teeth, indicating the age of three and half to four and half years old; and cows showed eight changed milk teeth, indicating the age of above five years old. Detition indicators were verified with household farmer information and records by the inseminators. The unhealthy and pregnant cows were excluded in this study.

2.2. Measured Traits

Measurements of heifer body dimensions were taken form July to August 2012 on each Ongole crossbred population including heifer body length (HBL), measured using a tape measure from distance between the site of pins (*tuber ischii*) to tail drop (*tuberositas humeri*), heifer chest girth (HCG), measured with a tape measure as body circumference of the chest just behind the foreleg. Animals were also weighed directly using the monitor digital electrical scale equipment tool with the maximum capacity of 2000 kg of the equipment tool. This equipment tool was eligibly used due to the maximum animal weight of less than 2000 kg. The accurate weight value in kilogram and gram digital unit of animal weighed was directly read on the monitor of electrical weighing indicator connecting with the floor cable of animal scale equipment tool, where the heifer was standing on.

2.3. Statistical Analysis

The data collected on each animal were analysed using the Insert Function Procedure of the related statistical category in datasheet of Microsofl Office Excel (2007) within the animal age groups. The interrelationship of body weights and body measurements were estimated by simple correlation and regression (Steel and Torrie, 1980). The best estimation equations for body weight from other traits (chest girth, body length, heifer body weight) as independent variables were determined. Descriptive statistics and regression analysis of body weight on each of the independent variable were performed using the Insert Function Procedure of the related statistical category in datasheet of Microsoft Office Excel (2007) referring to multiple regression model described by (Byrkit, 1987).

Correlation coefficients were also obtained from parameters. Linear regression effects of independent variables on live weight were included in the following model:

$$Y_i = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + e_i$$

Where Y_i is dependent variable of either rcalf durable parturition or calf birth weight of an *i-th* animal; b_0 is the intercept; b_1, $b_2$and $b_3$are the regression coefficients;X_1, X_2, andX_3, are independent variables of body dimensions of heifer chest girth, heifer body length, heifer live weight, and e_1 is the residual error term.

3. Result and Discussion

3.1. Calf Parturition and Body Measurements of Ongole Crossbred Heifers

Observation result of calf parturition durability (CPD) started by the existence of swell and mucus vulva of dam until fetus delivery from animal vulva in the limit time of less than 60 minutes without human assistance (n=36 heifers) were categorized as normal parturition. The heifers with CPD between 60 to 100 minutes (n=51 heifers) showing the restless sleeping, beat around the bush, and high frequent defecation without human assistance during parturition were categorized as slight calving difficulty. The total of animals (n=16 heifers) indicated by higher frequencies of the animal's beat around the bush, and higher frequent defecation during more than 100 minutes of CPD with human assistance to pull head and foreland of the fetus were categorized as high calving difficulty. This last CPD without human assistance carrying dam disability might cause death of both calf and its dam. In this study, the average and standard deviation of CPD were 69.39 minutes and 27.16 minutes, respectively (Table 1). The coefficient of variation of CPD was 39.15 percents, indicating high variability of CPD among heifers in the population. This high variability of CPD revealed that heifer parturition needs the intensive observation of breeder and solutions for alleviation of the factors affecting this variable, including heifer and calf body measurements.

In this study, the averages of heifer live weight (HLW), heifer body length (HBL) and heifer chest girth (HCG) were 368.8 kg, 139.52 cm and 174.72 cm, respectively (Table 1). The standard deviations of those variables were 29.64 kg, 5.20 cm and 13.19 cm, respectively. Furthermore, the coefficients of variation of HLW, HBL and HCG were 8.04 percents, 3.73 percents, and 7.55 percents, respectively. These coefficient values indicated the moderate variability of HLW and HCG, and the low variability of HBL among heifers in the population. Measurements of calf birth weight (CBW) showed the average of 26.1 kg with standard deviation of 1.55 kg. The coefficient of variation of this variable was 5.93 percents indicating the moderate variability (Table 1). These moderate variability of heifer body measurements and high variability of calf parturition durability revealed validity of further statistical analysis using the accurate and practicable multiple regression models for independent factors related to prediction of calf birth weight as the dependent variable.

3.2. Correlations of Variable Measurements in Ongole-Crossbred Dams and Their Calves

Correlation coefficients among variables of calf parturition durability (CPD), heifer chest girth (HCG), heifer body length (HBL) and heifer live weight (HLW) were presented in Table 2. High positive correlation coefficients of the variables were indicated between calf birth weight (CBW) and CPD of 0.96, and between HCG and HLW of 0.99. However, both variables of CBW and CPD were negatively correlated with both variables of HCG and HLW of -0.87 (Table 2). These correlation values revealed that the larger and the heavier the heifer bodies, the shorter the calf parturition durability, indicated also by lighter calf birth weight. Variable of HBL was lowly correlated with variables of CBW, CPD and HCG. At the adult age of animals, linear dimensions of body size had reached the constant point reflecting body skeleton dimensions to be heritable into the body size dimensions of the next generation (Sawanon et al., 2011). In this study, the observed body conditions of heifers were all under normal and consistent animal ages.

3.3. Calf Birth Weight Prediction Accuracy Using Calf Parturition Durability and Heifer Body Measurements

Simple linear regression model using single independent variable of calf birth weight (CBW) to predict calf parturition durability (CPD) showed that the determinant coefficient (R^2) was 0.92, indicating the accurate model. In this model, 92 percents of the changes of CPD (minute) were due to changes of the CBW (kg). Determinant coefficient (R^2) of single independent variables of heifer chest girth (HCG), heifer body length (HBL), and heifer live weight (HLW) to predict CPD were 0.76, 0.20 and 0.77, respectively (Table 3), indicating less accurate simple linear regression models.

Multiple linear regression model using two independent variables of calf birth weight (CBW) combined with either heifer body length (HBL) or heifer chest girth (HCG) to predict calf parturition durability (CPD) showed high determinant coefficient (R^2) of 0.93, indicating also the accurate multiple regression models. Multiple linear regression model using heifer's two independent variables of HCG and HBL to predict CPD showed moderate determinant coefficient of 0.76, indicating less accurate multiple regression model (Table 3).

Three independent variables of heifer body measurements

(HLW, HBL, HCG) included in the multiple regression model to predict calf parturition durability (CPD) showed moderate determinant coefficient of 0.77, indicating less accurate multiple regression model. However, two independent variables of heifer body measurements (HBL, HCG) combined with calf birth weight (CBW) in the multiple regression models to predict calf parturition durability (CPD) showed high determinant coefficient (R^2) of 0.93, indicating the accurate multiple regression models (Table 3). All those regression equation models with high determinant coefficients of 0.92-0.93 could be categorized into the accurate models for CPD estimation, but these models were categorized into less practicable models in rural areas due to limited availability of animal weighing scale machine on the field for calf and heifer weighing. Therefore, the most accurate and applicable multiple regression model was including the most easy measure independent variables of heifers to predict calf birth weight.

Three independent variables of heifer body measurements (HLW, HBL, HCG) were included in the multiple regression models to predict calf birth weight (CBW), showing high determinant coefficient of 0.93 and indicating high accurate multiple regression model. The same model including two independent variables of heifer body measurements (HBL, HCG) combined with CPD to predict CBW showed also high determinant coefficient of 0.93, indicating high accurate multiple regression model (Table3) with the model as follows:

$$CBW = 26.8862 + 0.00478\ X_1 – 0.02703\ X_2 + 0.04741\ X_3$$

Where, X_1 = heifer body length(HBL), X_2 = heifer chest girth(HCG) and X_3 = calf parturition durability(CPD).This high determination coefficient of 0.93 indicated that 93 percents of the changes of calf birth weight (kg) were due to changes of the HCG (cm), HBL (cm) and CPD(minute) following the equation model with the *intercept* of 26.8862;HBL coefficient b_1 of 0.00478;HCG coefficient b_2 of – 0.02703; and CPD coefficient b_3 of 0.04741; while the rest of 7percents of calf birth weight changes were due to other unknown factors.

Table 1. *Variables measured in heifers and calves related with reproduction process*

Variables	Animals (n)	Average	Standard deviation	Coefficient of variation (%)
Calf durable parturition (minute)	103	69.39	27.16537	39.15
Calf birth weight (kg)	103	26.1	1.54724	5.93
Heifer live weight (kg)	103	368.8	29.64027	8.04
Heifer body length (cm)	103	139.52	5.20388	3.73
Heifer chest girth (cm)	103	174.72	13.19136	7.55

Table 2. *Correlation coefficients among variables of Ongole crossbred dams and their calves*

Number of heifers	Variable	CPD	HCG	HBL	HLW
103	CBW	0,962	-0,869	-0,435	-0,871
103	CPD		-0,874	-0,452	-0,876
103	HCG			0,493	0,998
103	HBL				0,489

CPD = Calf Parturition Durability (*minute*); *HCG* = heifer chest girth (*cm*); *HBL* = Heifer body length (*cm*); *HLW* = Heifer live Weight (*kg*); *CBW* = Calf Birth Weight (*kg*).

Table 3. *Regression equation models for predicting calf birth weight using calf parturition durability and Ongole crossbred heifer body measurements*

Dependent variables (Y)	Independent variables (X)	Regression equation models	R^2
CPD	CBW	-385,182 + 17,4313 X	0,92
	HCG	675,2447 – 3,44342 X	0,76
	HBL	453,1829 – 2,72056 X	0,20
	HLW	415,1443 – 0,92607 X	0,77
	HCG (X_1), HBL (X_2)	688,7385 – 3,39105 X_1 – 0,1623 X_2	0,76
	CBW (X_1), HLW (X_2)	-257,0870 + 14,91991 X_1 – 0,1681 X_2	0,93
	CBW (X_1), HCG (X_2)	-209,8170 + 14,92609 X_1 – 0,6263 X_2	0,93
	HLW (X_1), HCG (X_2), HBL (X_3)	246,2853 - 1,58406 X_1 + 2,51841 X_2 - 0,20421 X_3	0,77
	CBW (X_1), HCG (X_2), HBL (X_3)	–199,36 – 14,9164 X_1 – 0,58978 X_2 – 0,11886 X_3	0,93
CBW	HLW (X_1), HCG (X_2), CPD (X_3)	16,584 - 0,03903 X_1 + 0,118319 X_2 - 0,046982 X_3	0,93
	HBL (X_1), HCG (X_2), CPD (X_3)	26,8862 + 0,00478 X_1 - 0,02703 X_2 + 0,04741 X_3	0,93

CPD = Calf Parturition Durability (*minute*); *HCG* = heifer chest girth (*cm*); *HBL* = Heifer body length (*cm*); *HLW* = Heifer live Weight (*kg*); *CBW* = Calf Birth Weight (*kg*).

4. Conclusion

Multiple regression equation model can be recommended to predict calf birth weight of Ongole crossbred heifers using heifer chest girth, heifer body length and calf parturition durability as independent variables as follows: Calf birth weight (*Y in kg*) = 26.8862 + 0.00478 heifer body length (X_1 *in cm*)– 0.02703 heifer chest girth (X_2 *in cm*)+ 0.04741 calf parturition durability (X_3 *in minute*) with determination coefficient (R^2) of 0.93. Determination coefficient of 0.93 indicated that 93 percents of the changes of calf birth weight (kg) were due to changes of the heifer chest girth (cm), heifer body length (cm) and calf parturition durability (minute) following the equation model with the *intercept* of 26.8862; heifer body length coefficient b_1 of 0.00478; heifer chest girth coefficient b_2 of – 0.02703; and calf parturition durability coefficient b_3 of 0.04741; while the rest of 7 percents of calf birth weight changes were due to other unknown factors.

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