Analysis of Newborn Calves Measurement for Early Selection Analysis in Aceh Bulls at The Breeding Station

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Abstract. Aceh cattle is one of Indonesian germplasms with many advantages for development in the tropics. The purpose of the study was to select Aceh bulls based on newborn calves measurements. Data comprised 294 calves from nine bulls. The variance components of heritability (h^2) and repeatability (r) estimation were obtained from data analysis using SPSS 16.0 software. Breeding value was estimated on the newborn calves measurement namely birth weight (BW), thoracic girth (TG), withers height (WH) and body length (BL). The genetic parameter values of newborn measurements were moderate category ($0.10< h^2 <0.30$) for heritability (h^2) and moderate ($0.10<r<0.30$) to high ($r>0.30$) for repetability (r). The average of newborn calves measurements was 13.99±1.96 kg (BW), 54.50±3.24 cm (TG), 56.37±3.41 cm (WH) and 45.13±2.86 cm (BL). Bull A (ID: P.075) was the best bull with cumulative breeding value 5.05.

Key words: Aceh cattle, newborn measurements, genetic parameters, breeding value

Abstrak. Sapi Aceh merupakan salah satu plasma nutfah Indonesia. Sapi ini memiliki banyak kelebihan untuk dikembangkan di daerah tropis. Tujuan penelitian ini adalah untuk menyeleksi pejantan sapi Aceh berdasarkan ukuran lahir pada pedet. Data yang digunakan terdiri dari 294 ekor pedet dari sembilan pejantan. Estimasi komponen ragam heritabilitas dan estimasi ripitabilitas dianalisis menggunakan perangkat lunak SPSS 16.0. Estimasi nilai pemuliaan dihitung berdasarkan ukuran lahir pedet: berat badan (BB), lingkar dada (LD), tinggi gumba (TG) dan panjang badan (PB). Nilai parameter genetik pada ukuran lahir termasuk kategori sedang ($0,10<h^2<0,30$) untuk heritabilitas (h^2) dan kategori sedang ($0,10<r<0,30$) sampai tinggi ($r>0,30$) untuk ripitabilitas (r). Rata-rata ukuran lahir pedet adalah 13,99±1,96 kg (BB), 54,50±3,24 cm (LD), 56,37±3,41 cm (TG) and 45,13±2,86 cm (PB). Pejantan A (ID: P.075) merupakan pejantan terbaik dengan nilai pemuliaan kumulatif sebesar 5,05.

Kata kunci: Sapi Aceh, ukuran lahir, parameter genetik, nilai pemuliaan

Introduction

Cattle farming and its development has continual demand in Indonesia as it is inseparable and integral part of agricultural farming system in Indonesia. There are about 14.90 million cattle farms, contributing more than 4.80% to the national GDP (Umartha, 2013). About 40% or 31 million Indonesian people are directly or indirectly engaged in livestock and poultry business. Aceh cattle is one of several Indonesian native cattle that play major role for beef production. This type of cattle adapts well to Indonesian environment, tropical climate and feedstuff. The population of Aceh cattle was recorded 483.628 in 2013 concentrated at Aceh province. Aceh cattle account for approximately 3% of the total cattle population in Indonesia. Despite the good adaptability, Aceh cattle productivity is still lower than other Indonesian local cattle. By improving the productivity of Aceh cattle, breeders are expected to gain interest in Aceh cattle, to increase Aceh cattle population and to reduce Indonesian dependency on imported beef and cattle. To date, however, significant

attention has been drawn to the perceived weaknesses of Aceh cattle, such as high calf mortality, small body size and slow growth rate.

Artificial insemination (AI) of Aceh cows/heifers using Aceh straw has become popular in Aceh province since 2013 following significant achievement in improving the cattle breeding system. The government and non government organizations are trying to spread it all over the Aceh province. Superior bull selection is very much essential to get superior progeny for both natural mating and AI. However, there is severe shortfall of breeding bulls all over the country, especially in the rural areas, where more than 75% bulls are being reared by the farmers. Same bulls have been used across generations with the increasing risk of inbreeding hence lower productivity and reproductive performance (Warwick et al. 1990). In order to improve the genetic make-up of cattle it is important to study calf body measurements as this will enhance proper selection of proven bulls. Among the growth traits, birth weight plays major role in determining preweaning weight of livestock production in early selection program (Falconer and Mackay, 1996).

Newborn calves measurements such as birth weight (BW), thoracic girth (TG), withers height (WH) and body length (BL) are easily measured and have medium to high heritability (Warwick et al., 1990), suggesting that these traits are likely to respond to selection. Heritability and repeatability estimates of newborn measurements (especially birth weight) are important because the estimates will determine if genetic selection is possible and the speed at which progress can be made through selection. Ranking seed stock animals on their estimated breeding value (EBV) sorts them based on progenies expected profitability for the targeted production system. In view of all these situations, present study was undertaken to evaluate the Aceh bulls based on body measurements of their progeny in the breeding center, and to estimate heritability for newborn calves measurement and to predict EBV of Aceh bulls for evaluation of the Aceh superior bulls.

Materials and Methods

Source of data. The experiment was conducted at Indrapuri Breeding and Forages Center (IBFC) of Aceh Cattle, Indrapuri district, Aceh province, Indonesia. Nine Aceh bulls and 294 calves produced from those bulls and 250 cows constituted the experimental animals. The average of female animals were 3 years old with body condition score (BCS) 3. The data of newborn measurements newborn calves were collected such as birth weight (BW), thoracic girth (TG), withers height (WH) and body length (BL). Calves produced from the studied bulls from 2010 to 2014 were collected from the herd book maintained at Indrapuri's Breeding and Forages Centre (IBFC) of Aceh Cattle for analysis. Calves measurement (BW, TG, WH and BL) of female calves were corrected to male calf based on formula by Hardjosubroto (1994):

Corrected calves measurement =
female calves measurement x correction factor
Correction factor =
male calves measurement/female calves measurement

Data analysis. To evaluate genetic effect, Completely Randomized Design – One Way Classification models were performed to calculate the heritability of calf body measurements which enabled the implementation of additional random effect. In the heritability model, sire was included as random effect in the model which account for the genetic effect. The total variance and covariance were sorted into additive and non additive components (Meyer, 1992)

$Y_{ij} = \mu + S_i + E_{ij}$

Where:

Y_{ij} = observation of the j^{th} individu on i^{th} sire
μ = common mean
S_i = effect of the i^{th} sire

E_{ij} = uncontrolled environmental deviations associated with each record which is assumed to be random, independent and normaly distributed with a mean 0 and a common variance.

Heritability was estimate from sire variance components using paternal halfsib correlation method, according to Becker (1992) as follows:

$$h^2 = \frac{4\hat{\sigma}_S^2}{\hat{\sigma}_S^2 + \hat{\sigma}_W^2}$$

Where:

h^2 = heritability

$\hat{\sigma}_S^2$ = sire variance component

$\hat{\sigma}_W^2$ = within progeny variance component

Standard errors for heritability estimated were approximated according to Warwick et al. (1990), Becker (1992) and Hardjosubroto (1994):

$$S.E\ h^2 = 4\sqrt{\frac{2(1-t)^2[1+(k-1)t]^2}{k(k-1)(S-1)}}$$

$$t = \frac{\hat{\sigma}_S^2}{\hat{\sigma}_S^2 + \hat{\sigma}_W^2}$$

$$k = \frac{1}{S-1}\left[N - \frac{\sum N_i^2}{N}\right]$$

Where:

SE = standard error

S = number of sire

k = number of progeny per sire

N = total of progeny

Repeatability was estimate using Interclass correlation method according to Hardjosubroto (1994) and Steel and Torrie (1995) as follows:

$$r = \frac{\sum X_1X_2 - \frac{\sum X_1 \sum X_2}{N}}{\sqrt{\left[\sum X_1 - \frac{(\sum X_1)^2}{N}\right]\left[\sum X_2 - \frac{(\sum X_2)^2}{N}\right]}}$$

Where:

$\sum X_1$ = total of first calf body measurements record

$\sum X_2$ = total of second calf body measurements record

N = total of paired data

Estimated breeding value and cummulative breeding value was calculated by formula referring to Hardjosubroto (1994) and Andoyo et al. (2010):

$$EBV = \frac{n\,h^2}{1+(n-1)r}\left(\bar{P} - \bar{\bar{P}}\right)$$

$CBV = EBV_{BW} + EBV_{TG} + EBV_{WH} + EBV_{BL}$

Where:

EBV = estimated breeding value

CBV = cumulative breeding value

N = total of progeny

n = number of progeny per sire

$\bar{P}$ = mean of calf body measurements per sire

$\bar{\bar{P}}$ = mean of pooled calf body measurements

BW = birth weight

TG = thoracic girth

WH = withers height

BL = body length

Results and Discussion

Calves Measurement. The BW of Aceh cattle in the present study (Table 1) was lowest than that of the other Indonesian breeds cattle. Average of BW for several Indonesian native cattle were 17.80±1.08 kg for Bali (Kaswati et al., 2013), 15.74±2.62 kg for Madura (Yusran et al., 1995), 26.10±1.55 kg for Ongole crossbred (Paputungan et al., 2015) and 15.00 kg for Pesisir (Wirdahayati and Bamualim, 2007). Newborn measurements of BW, WH and BL for Holstein calves were 33.90±0.98 kg; 74.60±6.7 cm and 67.2±6.2 cm, respectively (Ozkaya, 2013). Nugent et al. (1991) reported that calf measurements of BW, TG and BL for Angus were 35.40±3.80 kg; 75.10±3.80 cm and

52.10±3.50 cm respectively and Hereford were 35.20±4.60 kg; 73.30±2.20 cm and 52.50±1.70 cm respectively. Kolkman et al. (2010) reported that BW, TG, WH and BL of Belgian Blue newborn calves were 49.20±7.10 kg; 78.00±5.40 cm; 71.00±4.70 cm and 56.40±4.50 cm respectively. The BW of Aceh cattle (Bos indicus group) were lower than other groups such as Nellore (32.30±3.80 kg) and Red Chittagong (16.74±0.36 kg) as reported by Tatiane et al. (2014) and Rabeya et al. (2009). Most of Indonesian native cattle (Madura, Aceh, Pesisir, Ongole crossbred) were Bos indicus groups and these newborn measurements were lower than Bos taurus groups (Holstein, Angus, Hereford, Belgian Blue) as reported by Blakley and Bade (1991) and caused by difference in genetic, climate and enviromental adaption.

Genetic Parameters. The heritability (h^2) value of newborn measurements were moderate category (Table 2). The heritability of BW in Indonesian breeds cattle which using same method such as Bali (0.09±0.07), Simmental (0.11±0.09) and Madura were 0.41 (Gunawan and Jakaria, 2011; Suhada et al., 2009; Yusran et al., 1995). Heritability estimation of BW in Bos taurus groups such as Brahman were 0.48 (Pleasse et al., 2002), Red Chittagong were 0.49 (Rabeya et al., 2009), Tswana were 0.45 (Kethusegile, 2008) and Bokoloji were 0.10±0.02 (Shehu et al., 2008), Nellore were 0.32±0.02 (Tatiane et al., 2014). Therefore, h^2

Table 1. Mean of newborn calves measurement from nine Aceh sires at the breeding station

Parameters	Sires									Total
	A	B	C	D	E	F	G	H	I	
Body weight										
N	53	53	52	35	34	23	18	16	10	294
Mean (kg)	14.85	14.23	14.14	13.14	14.35	13.96	14.39	13.56	13.30	13.99
SD	1.99	2.36	1.85	1.48	1.95	2.18	2.03	1.63	2.11	1.96
Minimum	10.00	10.00	10.00	11.25	10.00	10.00	10.00	10.00	10.00	10.00
Maximum	19.00	18.00	18.00	10.00	20.00	18.00	19.00	16.00	16.00	20.00
CV (%)	13.43	16.58	13.12	17.00	13.60	15.65	14.13	12.03	15.87	13.98
Thoracic girth										
N	53	53	52	35	34	23	18	16	10	294
Mean (cm)	55.55	54.53	55.17	52.91	55.85	53.35	55.17	53.50	54.50	54.50
SD	3.60	4.02	3.15	2.91	3.04	2.69	2.87	2.78	4.09	3.24
Minimum	46.00	45.00	45.00	48.00	47.00	48.00	50.00	49.00	47.00	45.00
Maximum	65.00	62.00	60.00	58.00	64.00	57.00	62.00	58.00	59.00	64.00
CV (%)	6.49	7.38	5.72	5.51	5.44	5.04	5.21	5.20	7.50	5.95
Withers height										
N	53	53	52	35	34	23	18	16	10	294
Mean (cm)	58.06	56.51	56.67	55.21	56.26	56.09	57.61	56.44	54.50	56.37
SD	3.54	3.87	2.53	3.49	2.56	2.78	3.36	3.08	5.50	3.41
Minimum	50.00	48.00	51.00	42.00	47.00	52.00	50.00	51.00	40.00	40.00
Maximum	65.00	64.00	64.00	59.00	61.00	62.00	63.00	64.00	59.00	65.00
CV (%)	6.10	6.85	4.46	6.32	4.55	4.95	5.84	5.45	10.10	6.05
Body length										
N	53	53	52	35	34	23	18	16	10	294
Mean (cm)	46.92	45.04	44.85	43.86	46.21	45.00	44.78	45.31	44.20	45.13
SD	4.33	3.26	2.53	2.66	2.68	2.83	2.65	1.66	3.16	2.86
Minimum	42.00	38.00	41.00	40.00	41.00	40.00	40.00	42.00	40.00	38.00
Maximum	59.00	52.00	54.00	51.00	51.00	50.00	51.00	48.00	49.00	59.00
CV (%)	9.22	7.23	5.64	6.06	5.81	6.29	5.91	3.67	7.14	6.34

N: total of progeny; SD: standard deviation; CV: coefficient of variation

value of BW in Bos taurus groups such as N'Dama (0.10±0.05), West African Shorthorn (0.45±0.08), Gelbvieh crossbred (0.30±0.03) and South African Limousine were 0.09±0.02 (Abdullah and Olutogun, 2006; Marquez et al., 2004; Niekerk and Neser, 2006). However, h^2 of BW was be closely in agreement with data (0.21±0.03) reported by Neser et al. (2012) in Brangus (*Bos indicus* x *Bos taurus*) cattle and suggesting that all studied traits could be included in beef cattle improvement programs, because the direct selection for any traits could result in genetic progress.

Differences found among result are probably due to breed differences, statistical analysis (sire or animal models), selection pressure within population, sample size and environmental effect (Kethusegile, 2008). Similar results of the discrepancies of the value could be due to differences in genetic variation among the populations, differences in statistical models used for analysis of the same breed to different enviromental conditions. The low values of h^2 obtained could be either due to deterioration in management resulting to poor nutritional status of the animals or due to the use of same sire for a number of years which could result in inbreeding and decrease in additive genetic variation. Low h^2 value of BW suggested that selection on the basis of individual performance will not be effective in achieving increased gain in BW (Susanne, 2003). Praharani (2004) argued that the low rates of genetic progress such as on BW was because breeders were not selecting them or that selection applied was inefective because of lower h^2 value. Lower h^2 value might be due to small number of data or erratic nature of BW which impact to large standard error (SE). High SE due to high difference between maximum and minimum range of BW was observed within the Aceh calves because of on-station environmental stress faced by their cows (dams) during feeds crisis period. Praharani (2004) and Susanne (2003) also explained the lower h^2 value might be due to 1) little number of animals aviable for estimations, 2) the existence of a very important enviromental influence on these traits, 3) the need for better adjustment of fixed effects, 4) failure to consider the influence of some other traits on BW. The higest value (0.33) of repeatability (r) for newborn calves measurements showed in BW (Table 2). Nugent et al. (1991) reported that r value of newborn calves measurement: BW, BL, TG for Angus were 0.19; 0.03; 0.02 respectively and Pooled Hereford were 0.22; 0.19; 0.03 respectively. Highest r values of BW were related to similar traits (BW) for next generation (progeny) from each cows.

Table 2. Variance component of heritability (h^2) and repeatability (r) estimation for newborn measurement in Aceh cattle

Parameters	N			σ_S^2	σ_w^2	Value	SE
	Sire	Dam	Progeny				
Heritability							
Birth weight	9	-	294	7.93	6.01	0.24	0.17
Thoracic girth	9	-	294	33.18	31.92	0.16	0.14
Withers height	9	-	294	45.18	44.00	0.15	0.14
Body length	9	-	294	25.19	24.20	0.13	0.12
Repeatability							
Birth weight	-	21	42	-	-	0.33	-
Thoracic girth	-	21	42	-	-	0.12	-
Withers height	-	19	38	-	-	0.13	-
Body length	-	21	42	-	-	0.14	-

σ_S^2 : variance of sires; σ_w^2 : variance of progenies N: total of observation; SE: standard error

Table 3. Estimated breeding values (EBV) and cumulative breeding value (CBV) of Aceh bulls based on newborn calves measurement

Sires	EBV (rank)				CBV (rank)
	BW	TG	WH	BL	
A	0.60 (1)	1.23 (1)	1.73 (1)	1.49 (1)	5.05 (1)
B	0.17 (4)	0.04 (5)	0.14 (4)	-0.07 (4)	0.28 (5)
C	0.10 (5)	0.78 (3)	0.31 (3)	-0.23 (7)	0,96 (4)
D	-0.58 (9)	-1.75 (9)	-1.12 (8)	-1.00 (9)	-4.45 (9)
E	0.25 (3)	1.48 (2)	-0.11 (6)	0.85 (2)	2.47 (2)
F	-0.02 (6)	-1.16 (8)	-0.25 (7)	-0.10 (5)	-1.53 (7)
G	0.26 (2)	0.63 (4)	1.04 (2)	-0.24 (6)	1.69 (3)
H	-0.28 (7)	-0.91 (7)	0.06 (5)	0.12 (3)	-1.01 (6)
I	-0.42 (8)	0.00 (6)	-1.29 (9)	-0.53 (8)	-2.24 (8)

BW: birth weight (kg); WH: withers height (cm); TG: thoracic girth (cm); BL: body length (cm)

Breeding Value. Breeding value of newborn traits of Aceh bulls is shown in Table 3. Cumulative breeding value (CBV) of newborn calves measurement range from -4.45 to 5.05. The highest and lowest CBV value were found on bull A (ID: P.075) and D (ID: A.0691) respectively. Negative values were found on four bulls (D,F,H,I) based on EBV_{BW} and CBV, therefore the similar ranking (33.33%) were found on bull A, D and I. It was concluded that selection of bulls based on CBV gives more accurate than EBV_{BW} for all bulls evaluation. Yusran et al. (1995) reported that the EBV_{BW} of three Madura bulls without r value (different method) were -1.17; 0.21 and 1.90. Computing EBV using r value more accurate because the genetic additive variance (σ^2) from cows were calculated (Warwick et al., 1990). Negative value on EBV or CBV indicated that the calves performance of some bull was under population rank and should be culled (Hardjosubroto, 1994). Selection of Aceh cattle based on CBV value will increase the calves shape. Moderate h^2 value for newborn measurements in Aceh cattle indicated that those traits could be increased by CBV. However, selection cows based on BCS or body measurements (especially pelvic width) were recommended to reduce dystochia (Nugent et al., 1991). Using Bull A as the breeding bull gave genetic improvement maximum 0.30 kg (BW), 0.62 cm (TG), 0.87 cm (WH) and 0.75 (BL) for the newborn calf.

Conclusion

The genetic parameters of newborn calves measuremens were moderate category for heritability and moderate to high for repeatability. Selection for the best or worst Aceh bulls could be done using CBV or EBV_{BW} alone at the breeding station. The highest (5.05) and lowest (-4.45) CBV values were found on bull A (ID: P.075) and D (ID: A.0691) respectively.

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