Selection of Bali cattle based on birth weight and calving interval records at West Nusa Tenggara Province of Indonesia

S. Said1,2,*, W.P.B. Putra1, M. Muzawar2 and S.A. Kantong3

1Laboratory of Animals Reproduction, Breeding and Cells Culture, Research Center for Biotechnology - Indonesian Institute of Sciences (LIPI), Jl. Bogor - Jakarta Km. 46. Cibinong, Bogor 16911, West Java - Indonesia
2Bureau of Artificial Insemination (BIBD Banyumulek), Department of Livestock and Animal Health of West Nusa Tenggara Province, Banyumulek Tour Rd. Banyumulek, Kediri 83362, West Nusa Tenggara - Indonesia
3Bureau of Breeding and Forages Center (BPT-HMT Serading), Department of Livestock and Animal Health of West Nusa Tenggara Province, Lintas Sumbawa Rd. Serading, Sumbawa 84381, West Nusa Tenggara - Indonesia

*Corresponding E-mail: syahruddinsaid01@gmail.com

Received October 29, 2019; Accepted February 14, 2020

ABSTRACT

Birth weight and calving interval are included of productivity traits that can be increased by selection program. However, the standard of desirable birth weight in cattle during the selection program is important to prevent dystocia incident risk. This study was aimed to select Bali cattle (Bos javanicus) based on Estimated Breeding Value of birth weight (EBV_{BW}) and Most Probable Producing Ability of birth weight (MPPA_{BW}) and calving interval (MPPA_{CI}). Total of 758 records data of BW were collected from Lombok and Sumbawa islands, West Nusa Tenggara Province. Research showed the average of BW in Bali calves were 15.69±1.70 kg (Lombok) and 13.49±1.89 (Sumbawa). Rerata JK induk sapi dari kedua pulau sekitar 385 hari. Selanjutnya, nilai heritabilitas (h^2) BL pada kedua pulau sekitar 0,90. Nilai repetitabilitas (r) BL pada kedua pulau 0,30. Sementara itu, nilai r JK di pulau Sumbawa 0,39. PNP_{BL} pada sapi jantan tertinggi +4,25 kg dengan No ID: 0838 (Sumbawa). Nilai PNP_{BL} pada anak sapi tertinggi +6,07 kg dengan No ID: 0872 (Sumbawa). Nilai terendah KPPM_{BL} -25,70 hari pada induk No ID: 02076 (Lombok).

Kata kunci : Sapi Bali, berat lahir, jarak kelahiran, PNP, KPPM

ABSTRACT

Birth weight and calving interval are included of productivity traits that can be increased by selection program. However, the standard of desirable birth weight in cattle during the selection program is important to prevent dystocia incident risk. This study was aimed to select Bali cattle (Bos javanicus) based on Estimated Breeding Value of birth weight (EBV_{BW}) and Most Probable Producing Ability of birth weight (MPPA_{BW}) and calving interval (MPPA_{CI}). Total of 758 records data of BW were collected from Lombok and Sumbawa islands, West Nusa Tenggara Province. Research showed the average of BW in Bali calves were 15.69±1.70 kg (Lombok) and 13.49±1.89 (Sumbawa). The average of CI in Bali cows at both islands were about 385 days. In addition, the heritability (h^2) values of BW in both islands was about 0.90. The repeatability (r) values of BW in both islands were about 0.30. Meanwhile, the r
The value of CI in Sumbawa island was 0.39. The highest of EBV<sub>BW</sub> for sire was +4.25 kg by bull’s ID: 0838 (Sumbawa). Meanwhile, the highest of EBV<sub>BW</sub> for calves was +6.07 kg by calf’s ID: 0917 (Sumbawa). The highest of MPPA<sub>BW</sub> was +2.67 kg by cow’s ID: 0872 (Sumbawa). The lowest of MPPA<sub>CI</sub> was -25.70 days by cow’s ID: 02076 (Lombok).

**Keywords**: Bali cattle, birth weight, calving interval, EBV, MPPA.

**INTRODUCTION**

Bali cattle (*Bos javanicus*) is one of Indonesian native cattle that adapted well in Bali island. Bali cattle were declared as the Indonesian native cattle since year 2010 through decision of Indonesian Ministry of Agriculture No: 325/Kpts/OT.140/1/2010. Kaswati et al. (2013) reported that the average of weaning weight (205 days of age) and yearling weight (365 days of age) in Bali cattle at the breeding station (Bali island) were 88.59±16.15 kg and 131.12±25.50 kg respectively. In addition, Priyanto et al. (2019) reported that the average of slaughter weight, carcass weight and dressing percentage in Bali cattle were 275.56±61.93 kg, 141.04±35.61 kg and 50.95±3.49% respectively. Recently, Bali cattle was adapted well in many islands of Indonesia. Mansur et al. (2016) reported that the average of adult weight in Bali cattle at Barru Regency (Sulawesi island) were 158.63±34.27 kg (male) and 185.72±46.37 kg (female) Soekardono et al. (2009) reported that the average of body weight in Bali cows (about 1.5 - 2.0 years of age) were 157.00±20.59 kg (Lombok island) and 172.93±20.64 kg (Sumbawa island). In contrast, Samberi et al. (2010) reported that the reproductive efficiency (RE) in Bali cattle at Yapen archipelago (Papua Province) was 88.38% and included low category (RE < 100%).

Selection program to Bali cattle in the outside of Bali island is important to increase the growth traits in cattle. Selection in the livestock can be performed with conventional and molecular methods. The conventional selection in the cattle can be obtain using Estimated Breeding Value (EBV) and Most Probable Producing Ability (MPPA) analysis. Unfortunately, the study to select Bali cattle in the outside of Bali island with conventional method is not reported. Selection with conventional method is very complicated because this method need a large number of performance records and pedigree information. Therefore, most of the conventional selection study in Bali cattle were applied in the breeding station at Bali island. This study was carried out to select Bali cattle in Lombok and Sumbawa islands with conventional selection method. In this study, two records data of birth weight and calving interval were used to select Bali cattle in West Nusa Tenggara (WNT) province. Previous studies reported that BW of calves can be used as the selection criteria to select the best cattle (Bakir et al., 2004; Putra et al., 2015; Said et al., 2016). Moreover, the genetic correlation (rg) between birth and weaning weights in cattle were included of moderate to high categories (rg > 0.50) such as Brangus (0.78), Fogera (0.60) and 0.87 for Sumba Ongole (Neser et al., 2012; Bekele et al., 2016; Putra et al., 2018). Hence, the birth weight can be used as the selection criteria to increase weaning weight.

Moreover, the standard of desirable birth weight is important to prevent dystocia incident risk in cows. Meanwhile, the calving interval can be used as the selection criteria to obtain the cows with good reproductive trait. However, this study is important as the first conventional selection study in the Bali cattle outside of Bali island. In addition the results of this study can be used as the early information to select Bali cattle in WNT province with conventional method in the future.

**MATERIALS AND METHODS**

**Place and Samples**

The records data of birth weight in Bali cattle from year 2012 to 2018 were collected from Bureau of Artificial Inseminantion (BIBD Banyumulek) and Bureau of Breeding and Forages Center (BPT-HPT Serading). In addition, both institutions of BIBD Banyumulek and BPT-HPT Serading were located at Lombok and Sumbawa islands respectively (Figure 1). Therefore, both islands were included the main area of West Nusa Tenggara (WNT) province. The WNT province located between longitude 115° 46' - 119° 5’ E and latitude 8° 10' - 9° 5’ S about 11 to 3,726 m above the sea level. The maximum temperature in WNT province ranged between 31.1°C - 33.0°C and minimum temperature ranged between 22.8°C - 24.7°C. The humidity in WNT province about 79 to 85% and rainfall
average occurring 1212 to 1800 mm/year. Amount of 758 records data of birth weight (BW) in Bali cattle from BIBD Banyumulek (400 records) and BPT-HPT Serading (358 records) were used in this study. Birth weight measurement was taken from each calf with spring weighing scales.

Management of Animals

The Bali cattle in BIBD Banyumulek (Lombok island) were managed with semi-intensive management system in the farmer groups farm. The feed ration containing of king grass (*Pennisetum purpuphoides*), nutgrass (*Cyperus rotundus*), corncob and rice bran. Feed ration of corncob (4 kg), rice bran (6 kg). Thus, king grass (10 kg/head/day), corncob (5 kg/head/day), field grass (8 kg/head/day), and commercial concentrate (3 kg/head/day) were given to the cattle. The water was given by ad libitum and pregnancy and health examination were performed every month. The artificial insemination (AI) method was performed in this farm using Bali straw from BIBD Banyumulek. Therefore, the Bali cattle at BPT-HPT Serading (Sumbawa island) were kept by ranching management system. Every morning (09:00) to evening (16:00) cattle were managed in the pasture. The feed ration containing of elephant grass (*Pennisetum purpureum*), star grass (*Cynodon plectostachyus*) and rice bran. Feed ration of rice bran (1 kg/head/day) and concentrate (0.5 kg/head/day) were given to the cattle before managed in the pasture. The concentrate containing of water content (44.34%), dry matter (55.66%), crude protein (15.15%), TDN (80.07%), fat (13.15%) and rough fiber (14.26%). The natural mating method was performed in this breeding station using Bali bull. The herd was consisted of 1 bull and about 50 cows and every year the bull was exchanged. The water was given by ad libitum in the pasture and pregnancy and health examination were performed every month.

Standardization Data

Data of body weight (BW) in calves were standardized or corrected based on Hardjousubroto (1994) as follows:

$$ CF_{Sex} = \frac{X_{BW\ of\ male\ calves}}{X_{BW\ of\ female\ calves}} $$

where $CF_{Sex}$ is the correction factor of body. The calculation of $CF_{Sex}$ only used for female calves and important to reduce the data variation from sex effect.

Data Analysis

Data of BW were analyzed to describe the effect of sex, year, parity and season. Data of sex, year and parity were collected from records data of herds book. Thus the season of birth was classified into two categories of dry (April - September) and rainy (October - March). Thus, the data were analyzed using General Linear Model (GLM) with formula according to Steel and Torrie (1980) as follows:

$$ Y_{ijkl} = \mu + S_i + T_j + P_k + M_l + E_{ijkl} $$

Where $Y_{ijkl}$ is the observation of trait; $\mu$ is the common mean; $S_i$ is the effect of $i^{th}$ sex of calf; $T_j$ is the effect of $j^{th}$ year; $P_k$ is the effect of $k^{th}$ parity; $M_l$ is the effect of $l^{th}$ season; and $E_{ijkl}$ is the experimental error.

The heritability ($h^2$) value was analyzed using paternal halfsib correlation model through analysis of variance (ANOVA) method with a mathematical model according to Becker (1992) as follows:

$$ Y_i = \mu + a_i + e_i $$

**Figure 1.** The Breeding Tract of Bali Cattle in Lombok (A) and Sumbawa (B) Islands of Indonesia
Where $Y_i$ is the observation of trait; $\mu$ is the common mean; $\alpha_i$ is the effect of $i^{th}$ sire; and $e_i$ is the experimental error. Therefore, the $h^2$ value was estimated using formula according to Becker (1992) as follows:

$$h^2 = 4t$$

$$t = \frac{\sigma_s^2}{\sigma_s^2 + \sigma_w^2}$$

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

$$k = \frac{1}{S-1} \left( N - \sum n_i^2 \right)$$

Where $h^2$ is the heritability value; $\sigma_s^2$ is the variance component of sire; $\sigma_w^2$ is the variance component of individual; $\text{SE}(h^2)$ is the standard error of heritability; $S$ is the number of sire; $n_i$ is the number of progeny per sire; and $N$ is the total number of progeny.

The repeatability ($r$) value was analyzed using interclass correlation method based on two records of birth weight with a mathematical model according to Warwick et al. (1990) as follows:

$$r = \frac{\sum X_1 X_2 - (\sum X_1)(\sum X_2)}{\sqrt{\sum X_1^2 - (\sum X_1)^2/\sum X_2^2 - (\sum X_2)^2/N}}$$

Where $r$ is the repeatability; $X_1$ is the record of trait 1; $X_2$ is the record of trait 2; and $N$ is the number of data pairs.

The relative estimated breeding value (EBV) and Most Probable Producing Ability (MPPA) of birth weight were analyzed using mathematics formula according to Hardjosubroto (1994) as follows:

$$\text{EBV}_{\text{sire}} = \frac{n h^2}{1 + (n-1)r} \left( \overline{P}_{\text{prog}} - \overline{P}_{\text{pop}} \right)$$

$$\text{EBV}_{\text{prog}} = h^2 \left( \overline{P}_{\text{ind}} - \overline{P}_{\text{pop}} \right)$$

$$\text{MPPA} = \frac{n r}{1 + (n-1)r} \left( \overline{P}_{\text{prog}} - \overline{P}_{\text{pop}} \right)$$

Where $\text{EBV}_{\text{sire}}$ is the estimated breeding value of sire; $\text{EBV}_{\text{prog}}$ is the estimated breeding value of progeny; MPPA is the most probable producing ability of cow; $n$ is the number of progeny; $h^2$ is the heritability value; $r$ is the repeatability value; $\overline{P}_{\text{prog}}$ is the mean of trait in progeny; $\overline{P}_{\text{pop}}$ is the mean of trait in population; and $\overline{P}_{\text{ind}}$ is the trait of individual.

The relative accuracy (RA) calculation was performed in this study to measure the accuracy of selection for bulls using mathematical formula according to Hardjosubroto (1994) as follows:

$$\text{RA} = \frac{1}{2} \sqrt{\frac{n}{1 + (n-1)t}}$$

$$t = Rh^2 + c$$

Where $\text{RA}$ is the relative accuracy; $n$ is the number of progeny per sire; $R$ is 0.25 (halfsib correlation); $c$ is 0.00 (no correlation assumed) or 0.10 (correlation assumed).

**RESULTS**

**Birth Weight and Calving Interval**

The BW of Bali calves in Lombok was higher than Sumbawa island ($P<0.05$) as presented in Table 1. The BW in male calves were higher than female calves at both islands. The BW of calves in Lombok island at year 2017 to 2018 were about 16.00 kg and higher than year 2013 to 2015 (about 15.00 kg). In this study, records data of BW in Lombok island for year 2012 and 2016 were not available. Meanwhile, the highest of BW in calves at Sumbawa island was showed at year 2012 and 2015 (about 15.00 kg). Commonly, the CI of calves that born in dry and rainy seasons were similar in both islands (about 385 days). According to the records data, most of calves in Lombok and Sumbawa islands were born in season of rainy (62%) and dry (92%) respectively. According to Table 1, three factors of sex, year and parity were affected to BW in both island. Meanwhile, factor of season was affected to BW in Sumbawa island.

**Heritability and Repeatability**

The $h^2$ value of BW in both islands were about 0.90 as presented in Table 2. Meanwhile, the $r$ value of BW in both islands were about 0.30. Despite, the $r$ value of CI in Sumbawa island was 0.39. In this study, the estimation of $r$ value for CI in Lombok island was not performed because of no parallel parity records data. The SE values of
Estimated Breeding Value and Most Probable Producing Ability

The EBV_{BW} in Bali bull at Lombok and Sumbawa islands were presented in Table 3 and Table 4 respectively. Total records data of BW that used for $h^2$ and r estimations were 633 records and 120 records respectively. Thus, the $h^2$ value in this study was obtained using dataset from 13 bulls (Lombok island) and 7 bulls (Sumbawa island). Selection of Bali bulls in this study based on the two parameters of EBV Sire and RA. Bali calves were selected based on EBV prog for BW. Bali cows were selected by MPPA BW and MPPA CI.

The highest of relative EBV_{BW} for sire at Lombok and Sumbawa islands were +3.94 kg (bull’s ID: 11509d004) and +4.25 kg (bull’s ID: 11509d001).
0838) respectively. Total of 25 bulls in Lombok island were evaluated in this study and only 11 bulls were ranked through RA values. Meanwhile, the highest of EBV$_{BW}$ for calves in Lombok and Sumbawa islands were +3.74 kg (calf’s ID: sm0007) and +6.07 kg (calf’s ID: 0917) respectively (Table 5). Overall the EBV$_{BW}$ for sire and calves in Lombok island were higher than Sumbawa island as show in Figure 2.

Moreover, the highest of MPPA$_{BW}$ in Lombok and Sumbawa islands were +2.28 kg (cow’s ID: 02009) and +2.67 kg (cow’s ID: 0872) respectively (Table 6). In addition, the lowest MPPA$_{CI}$ in Lombok and Sumbawa islands were -25.70 days (cow’s ID: 02076) and -26.59 (cow’s ID: 0583) respectively (Table 7). Overall the MPPA$_{BW}$ in Lombok island was higher than Sumbawa island as shows in Figure 3. In addition, overall the MPPA$_{CI}$ in both island were similar.

**DISCUSSIONS**

The different of BW of Bali calves between Lombok and Sumbawa islands can be caused by different management system. The semi-intensive management and AI method can be caused the BW in Lombok island was higher than in Sumbawa island. Furthermore, the straws that used for AI were produced from selected bulls by BIBD Banyumulek. Tavares et al. (2012) reported that the BW of Bali calves in the breeding station at Bali island (BPTU-HPT Denpasar) were 18.37±1.65 kg (males) and 18.27±1.20 kg (females). Kaswati et al. (2013) reported that the corrected BW of Bali cattle in the BPTU-HPT Denpasar was 17.80±1.08 kg. Despite, Pemayun et al. (2014) reported that BW of Bali calves in the south Bali area were 15.62 kg (traditional system) and 16.94 kg (three strata forage system). Prasojo et al. (2010) reported that overall the BW of Bali calves in Gianyar, Bali and Badung (Bali island) was 18.40±1.60 kg. Gunawan and Jakaria (2011) reported that two factors of year and season were affected of BW in Bali calves at BPTU-HPT Denpasar. Factor of sex, year, parity and season also affect to BW in other Indonesian Ongole cross cattle (Hartati et al., 2015). Meanwhile, Putra et al. (2018) reported that two factors of year and season were affected of BW in Sumba Ongole cattle. According to the previous studies, the BW of Bali calves in Bali island was highest than in two islands at WNT province. The intensive selection program with good breeding practices for Bali cattle in BPTU-HPT Denpasar was caused the highly of BW in Bali island.

Siswanto et al. (2013) reported that the CI of Bali cattle in BPTU-HPT Denpasar was 350.46±27.98 days and lower than in WNT province. In addition, Pemayun et al. (2014) reported that CI of Bali cattle in the south Bali area were 402 days (traditional system) and 384 days (three strata forage system). Soekardonoto et al. (2009) reported that the CI of Bali cattle in Lombok Barat (Lombok island) and Dompu (Sumbawa island) were 457.80 days and 470.10 days respectively. Despite, the CI of Bali cattle in Yapen archipelago (Papua) and Banyuasin (Sumatera island) were 410.40 days and 428.10 days respectively (Samberi et al., 2010; Susanti et al., 2015) and higher than in this study. The CI of Bali cattle in this study were similar to the Bali cattle in the south Bali area that managed with three strata forage system.

The h$^2$ value of BW in Bali cattle at WNT province was included of high category (h$^2$>0.30) with low of SE value. High category of h$^2$ value for BW was showed in Red Chittagong (0.50), Horro (0.62), Nellore (0.37), Bali (0.85), Brahman

| Location          | N$_{S}$ | N$_{Prog}$ | $\sigma^2_{S}$ | $\sigma^2_{W}$ | k  | h$^2$±SE | r (N) |
|-------------------|---------|------------|----------------|----------------|----|----------|-------|
| Lombok island     | 13      | 284        | 0.43           | 1.37           | 22 | 0.96±0.36| 0.36 (51) |
| Sumbawa island    | 7       | 349        | 0.90           | 2.75           | 50 | 0.99±0.48| 0.37 (69) | 0.39 (41) |

N$_{S}$: number of sire; N$_{Prog}$: number of progeny; $\sigma^2_{S}$: variance component of sire; $\sigma^2_{W}$: variance component of individu; k: constanta; h$^2$: heritability; SE: standard error; r: repeatability; N: number of data pairs; BW: birth weight; CI: calving interval
Table 3. Estimated Breeding Value of Birth Weight (Corrected) and Relative Accuracy of Bali Bulls in Lombok Island

| Rank | Sire     | N<sub>Prog</sub> | X<sub>CBW</sub> (kg) | EBV<sub>Sire</sub> (kg) | Relative accuracy<sup>c = 0.00</sup> | Relative accuracy<sup>c = 0.10</sup> | Remark      |
|------|----------|------------------|----------------------|-------------------------|--------------------------------------|--------------------------------------|-------------|
| 1    | 11509d004| 30               | 17.66                | +3.94                   | 0.97                                 | 0.83                                 | Accurate    |
| -    | 01738    | 2                | 18.38                | +3.21                   | 0.64                                 | 0.61                                 | Not accurate|
| -    | 03724    | 3                | 17.92                | +3.04                   | 0.71                                 | 0.67                                 | Not accurate|
| -    | 0874     | 4                | 17.46                | +2.52                   | 0.76                                 | 0.70                                 | Not accurate|
| 2    | 11012J003| 84               | 17.01                | +2.39                   | 1.00                                 | 0.85                                 | Accurate    |
| -    | sm201401 | 2                | 17.00                | +1.27                   | 0.64                                 | 0.61                                 | Not accurate|
| -    | 0750     | 2                | 17.00                | +1.27                   | 0.64                                 | 0.61                                 | Not accurate|
| -    | 241015   | 6                | 16.71                | +1.25                   | 0.83                                 | 0.75                                 | Doubting    |
| -    | ni201412 | 2                | 16.80                | +0.99                   | 0.64                                 | 0.61                                 | Not accurate|
| -    | 0886     | 2                | 16.80                | +0.99                   | 0.64                                 | 0.61                                 | Not accurate|
| -    | 01678    | 6                | 16.54                | +0.91                   | 0.83                                 | 0.75                                 | Doubting    |
| 3    | 01822    | 21               | 16.31                | +0.52                   | 0.95                                 | 0.82                                 | Accurate    |
| 4    | 03889    | 30               | 16.22                | +0.31                   | 0.97                                 | 0.83                                 | Accurate    |
| -    | pb201304 | 9                | 16.05                | -0.11                   | 0.88                                 | 0.78                                 | Doubting    |
| 5    | 01026    | 18               | 16.04                | -0.15                   | 0.94                                 | 0.81                                 | Accurate    |
| -    | 03773    | 3                | 15.85                | -0.42                   | 0.71                                 | 0.67                                 | Not accurate|
| -    | 0686     | 2                | 15.75                | -0.59                   | 0.71                                 | 0.67                                 | Not accurate|
| 6    | 02641    | 22               | 15.71                | -0.97                   | 0.95                                 | 0.82                                 | Accurate    |
| 7    | 03452    | 35               | 15.56                | -1.38                   | 0.98                                 | 0.83                                 | Accurate    |
| -    | 02641    | 4                | 15.15                | -1.75                   | 0.76                                 | 0.70                                 | Not accurate|
| 8    | 02620    | 12               | 15.31                | -1.83                   | 0.91                                 | 0.80                                 | Accurate    |
| 9    | 02951    | 34               | 15.35                | -1.91                   | 0.98                                 | 0.83                                 | Accurate    |
| -    | 01907    | 9                | 14.86                | -2.76                   | 0.88                                 | 0.78                                 | Doubting    |
| 10   | 03482    | 27               | 14.92                | -2.95                   | 0.97                                 | 0.83                                 | Accurate    |
| 11   | 00723    | 19               | 13.77                | -5.69                   | 0.94                                 | 0.82                                 | Accurate    |

<sup>N<sub>Prog</sub></sup>: number of progeny; <sup>X<sub>CBW</sub></sup>: means of corrected birth weight; <sup>EBV<sub>Sire</sub></sup>: estimated breeding value of sire; Accurate (RA > 0.80)

(0.57) and Bonsmara (0.36), Friesian Holstein (0.40) and Sumba Ongole (0.66) cattle (Afroz et al., 2011; Abera et al., 2013; Regatieri et al., 2012; Kaswati et al., 2013; Rakwadi et al., 2014; Rahman et al., 2015; Putra et al., 2018). Moderate of h<sup>2</sup> value (0.10 < h<sup>2</sup> < 0.30) for BW was showed in Vrindavani (0.29), Tuli (0.21), Charolais (0.23) and Ongole cross (0.28) cattle (Singh et al., 2010; Rakwadi et al., 2014; Vostry et al., 2015; Hartati et al., 2015). Low of h<sup>2</sup> value (h<sup>2</sup> < 0.10) for BW was showed in Aceh (0.06) and Fogera (0.06) cattle (Sari et al., 2016; Bekele et al., 2016). High h<sup>2</sup> value of BW suggested that selection based on this trait will be effective to increase gain of BW. The variation of h<sup>2</sup> value in this study compared to previous studies might be due to different of

Selection of Bali Cattle Based on Birth Weight and Calving Interval (S. Said et al.) 21
breeds, environment, number of data structure and statistical analysis used for estimation (Hossain et al., 2018). The SE value in this study was lower than $h^2$ value and can be suggested that the $h^2$ estimation in this study was accurate. Furthermore, the $h^2$ value of BW in this study can be used as the one of the technical coefficient in the conventional selection program of Bali cattle at WNT province in the future.

The $r$ value of BW and CI in Bali cattle at WNT province was included of high category ($r$>0.30). Setiyabudi et al. (2016) obtained the high category of $r$ value for BW in Bali cattle at BPTU-HPT Denpasar (0.99) and higher than in this study. High $r$ value for BW was reported in Friesian Holstein (0.34), Aceh (0.36), and Madura cows (0.46) (Bakir et al., 2004; Putra et al., 2014; Tribudi and Prihandini, 2019). Meanwhile,

### Table 4. Estimated Breeding Value of Birth Weight (Corrected) and Relative Accuracy of Bali Bulls in Sumbawa Island

| Rank | Sire | $N_{Prog}$ | $X_{CBW}$ (kg) | $EBV_{Sire}$ (kg) | Relative accuracy | Remark |
|------|------|------------|----------------|-------------------|------------------|--------|
|      |      |            |                |                   | $c = 0.00$ | $c = 0.10$ |
| 1    | 0838 | 42         | 15.47          | +4.25             | 0.97            | 0.83   | Accurate |
| 2    | 0948 | 43         | 15.30          | +3.81             | 0.97            | 0.83   | Accurate |
| 3    | 1454 | 79         | 13.85          | +0.09             | 0.99            | 0.84   | Accurate |
| 4    | 0631 | 41         | 13.69          | -0.33             | 0.97            | 0.83   | Accurate |
| 5    | 0431 | 69         | 13.00          | -2.14             | 0.98            | 0.84   | Accurate |
| 6    | 0980 | 51         | 12.95          | -2.24             | 0.90            | 0.83   | Accurate |
| 7    | 0383 | 33         | 12.73          | -2.76             | 0.96            | 0.83   | Accurate |

$N_{Prog}$: number of progeny; $X_{CBW}$: means of corrected birth weight; $EBV_{Sire}$: estimated breeding value of sire; Accurate (RA > 0.80)

### Table 5. The Best Five Bali Calves With Positive Estimated Breeding Value for Corrected Birth Weight

| Location / Calf | Sire / Straw | Dam | Sex | CBW (kg) | $EBV_{Prog}$ (kg) |
|-----------------|--------------|-----|-----|----------|-------------------|
| Lombok island   |              |     |     |          |                   |
| sm0007          | 11012I003    | 02009 | Male | 20.00    | +3.74             |
| 0948            | 241015       | 01003 | Female | 18.90   | +2.69             |
| 03936           | 03452        | 0556  | Male | 18.00    | +1.82             |
| 08761           | 0886         | 0876  | Female | 17.85   | +1.68             |
| an201507        | 02951        | bn201101 | Female | 16.80   | +0.67             |
| Sumbawa island  |              |     |     |          |                   |
| 0917            | 0838         | 0422  | Female | 15.23    | +6.07             |
| 0561            | 0948         | 0900  | Female | 16.80    | +5.13             |
| 0601            | 1454         | 0327  | Male | 15.00    | +5.09             |
| 0909            | 0838         | 0900  | Male | 16.50    | +4.14             |
| 0555            | 0948         | 0898  | Female | 16.80   | +3.99             |

CBW: corrected birth weight; $EBV_{Prog}$: estimated breeding value of progeny
moderate r value (0.10<r<0.30) for BW was showed in Red Sindhi (0.17), Friesian Holstein (0.21), Jersey (0.13), Sumba Ongole (0.10) and Friesian cross (0.30) cows (Mustafa et al., 2002; Aksakal and Bayram, 2009; Nandolo, 2015; Said et al., 2016; Islam et al., 2017).

The r values for CI in this study was included of high category (r>0.30). Recently, the new study to report the r value for CI of Bali or native cattle in Indonesia are not reported. However, previous studies reported that high r value for CI were showed in Thari (0.35) and Kedah-Kelantan (0.34) and White Fulani (0.43) cattle (Sivarajasingam, 1975). The moderate r value (0.10 < r < 0.30) was showed in Tunisian Holstein (0.15), Ethiopian Holstein (0.23) and Mpwapwa (0.10) cattle (M’Hamdi et al., 2011; Ayalew et al., 2017; Chawala et al., 2017). The low r value (r < 0.10) for CI were showed in Japanese Black (0.09), crossbred beef (0.04),

Table 6. The Best Five Bali Cows Based on Most Probable Producing Ability With Two Records Data of Birth Weight

| Location / Cows | N_{prog} | X_{CBW} (kg) | MPPA_{BW} (kg) |
|-----------------|----------|--------------|-----------------|
| Lombok island   |          |              |                 |
| 02009           | 2        | 20.00        | +2.28           |
| 02054           | 2        | 19.00        | +1.75           |
| 01024           | 2        | 18.50        | +1.49           |
| 02076           | 2        | 18.00        | +1.22           |
| 02019           | 2        | 17.00        | +0.69           |
| Sumbawa island  |          |              |                 |
| 0872            | 2        | 18.45        | +2.67           |
| 0907            | 2        | 17.35        | +2.08           |
| 0895            | 2        | 16.85        | +1.81           |
| 0896            | 2        | 16.80        | +1.78           |
| 0319            | 2        | 16.00        | +1.35           |

N_{prog} : number of progeny; X_{CBW} : means of corrected birth weight; MPPA_{BW} : most probable producing ability of birth weight.
Iranian Holstein (0.06), Overo Colorado (0.05), Turkish Holstein and Czech Holstein (0.09) cattle. (Oyama et al., 2002; Silva et al., 2015; Rahbar et al., 2016; Montaldo et al., 2017; Ersöz and Ertuğrul, 2018; Brazakova et al., 2019). High $r$ value in this study can be suggested that overall cows had high repetition value (probability) to perform similar records data of BW and CI traits. Therefore, selection of Bali cows can be performed based on two records data of both traits.

EBV$_{BW}$ and MPP$_{ABW}$ values of Bali cattle in this study were higher than reported in the Aceh bull (+0.42 kg), calf (-0.02 kg) and cow (+0.001 kg) in BPTU-HPT Indrapuri (Putra et al., 2014). Hilalah et al. (2018) reported that the highest EBV$_{bw}$ of Bali calf in BPTU-HPT Denpasar was +0.46 kg and lower than in this study. Intaratham

### Table 7. The Best Five Bali Cows Based on Most Probable Producing Ability of Calving Interval

| Location / Cows     | N | $X_{CI}$ (days) | MPPA$_{CI}$ (days) |
|---------------------|---|----------------|--------------------|
| Lombok island*      |   |                |                    |
| 02076               | 1 | 320.00         | -25.70             |
| 602064              | 1 | 329.00         | -22.19             |
| 01023               | 1 | 340.00         | -17.90             |
| 01025               | 1 | 352.00         | -13.22             |
| 02010               | 1 | 378.00         | -3.08              |
| Sumbawa island      |   |                |                    |
| 0583                | 2 | 338.00         | -26.59             |
| 0482                | 2 | 345.00         | -22.66             |
| 0022                | 2 | 348.00         | -20.98             |
| 0397                | 2 | 350.00         | -19.86             |
| 0354                | 2 | 353.00         | -18.18             |

**Based on the $r$ value from Sumbawa island; N: number of records data; $X_{CI}$: means of calving interval; MPPA$_{CI}$: most probable producing ability of calving interval

---

**Figure 2.** The Histograms of Absolute Most Probable Producing Ability (MPPA) for Body Weight (BW) and Calving Interval in Bali Cows at WNT Province
et al. (2008) reported that the highest EBV\textsubscript{BW} in Northeastern Thai indigenous cattle was reached of +74 kg and lower than in this study (+6.07 kg). In addition, Atil et al. (2005) reported that the EBV\textsubscript{BW} in Friesian Holstein calf was ranged from -3.12 to +2.99 kg. According to Table 3, the highly of RA values (RA>0.80) were reached in the sires with a large number of progenies. Therefore, low RA value in a bull indicates that selection in this bull is not accurate because of less number of progeny for analysis. (Putra et al., 2015).

**CONCLUSION**

The \( h^2 \) value of BW in Bali cattle at WNT province included of high category and can be described that BW of Bali cattle in this province can be increased based on BW. The \( r \) value of BW and CI in Bali cattle at WNT province included of high category and described that cows evaluation can be conducted with two records data of these traits. The cattle with positive of EBV and MPPA values can be used for breeding program in WNT province.

**ACKNOWLEDGMENTS**

We gratefully acknowledged the Research Center for Biotechnology, Indonesian Institute of Sciences, BIBD Banyumulek and BPT-HPT Serading for records data support. Author gratitude is also expressed to members of Animal Research Group in Research Center for Biotechnology, Indonesian Institute of Sciences.

**REFERENCES**

Abera, H., S. Abegaz, and Y. Mekasha. 2013. Influence of non-genetic factors on growth traits of Horro (Zebu) and their crosses with Holstein Friesian and Jersey cattle. Glob. J.Anim. Bred. Genet. 1(1): 31-36.

Afroz, M.A., M.A. Haque and A.K.F.H. Bhuiyan. 2011. Estimation of heritability for growth traits of Red Chittagong cattle in a nucleus herd. Bang. Vet. 28(1):39-46.

Aksakal, V. and B. Bayram. 2009. Estimates of genetic and phenotypic parameters for the birth weight of calves of Holstein Friesian reared organically. J. Anim. Vet.Adv. 8(3):568-572.

Atil, H., A.S. Khattab and L. Badawy. 2005. Genetic parameter of birth and weaning weights for Friesian calves by using an animal model. Arch. Tierz. 48(3): 261-269.

Ayalew, W., M.Aliy and E. Negussie. 2017. Estimation of genetic parameters of the productive and reproductive traits in Ethiopian Holstein using multi-trait models. Asian-Australas. J. Anim. Sci. 30(11):1550-1556.

Bakir, G., A. Kaygisiz and H. Ülker. 2004. Estimates of genetic and phenotypic parameters for birth weight in Holstein Friesian cattle. Pak. J. Biol. Sci. 7(7):1221-1224.

Becker, W.A. 1992. Manual of Quantitative Genetics. Pullman, Washington.

Bekele, A., Z. Wuletaw, A. Haile, S. Gizaw and G. Mekuriaw. 2016. Genetic parameter estimation of pre weaning growth traits of Fogera cattle at Metekel Ranch, Northwest Ethiopia. IJSRST. 2: 15-21.

Brazakova, M., L. Zavadilova, J. Pribyl, P. Pesek, E. Kasna and A. Kranjcevicova. 2019. Estimation of genetic parameters for female fertility traits in the Czech Holstein population. Czech J. Anim. Sci. 64:199-206.

Chawala, A.R., G. Banos, D.M. Komwihangilo, A. Peters, and M.G.G. Chagunda. 2017. Phenotypic and genetic parameters for selected production and reproduction traits of Mpwapwa cattle in low-input production system. S. Afr. J. Anim. Sci. 47(3):307-319.

Ersöz, T and O. Ertuğrul. 2018. Estimation of the repeatability of Holstein milk yields via various statistical methods. J. Agric. Agric. Fac. Gaziosmanpasa. Univ. 35(1):75-84.

Gunawan, A and Jakarta. 2011. Genetic and non-genetic effects on birth, weaning, and yearling weights of Bali cattle. Med. Pet. 34(2): 93-98.

Hardjosubroto, W. 1994. Aplikasi Pemuliabiakan Ternak di Lapangan.Gramedia Widiasarana Indonesia, Jakarta.

Hartati, Muladno, Jakarta, R. Priyanto, A. Gunawan, Aryogi and C. Talib. 2015. Heritability estimation and non-genetic factors affecting production traits of Indonesian Ongole cross. JITV. 20: 168-174.

Hilalah, N., I.N. Ardika and D.A. Warmingadi. 2018. The estimation of breeding value of Bali cattle body weight at Balai Pemibitan Ternak Unggul dan Hijauan Pakan Ternak (BPTU-HPT) Denpasar. Pet. Trop. 6(1):1-11.

Hossain, S.M.J., A.K.F.H. Bhuiyan, M.A. Kabir,
M.F.H. Miraz and M. Habib. 2018. Growth performance of Red Chittagong cattle based on phenotypic and genetic parameters. Int. J. Anim. Sci. 2: 1025.

Intaratham, W., S. Koonawootrittriron, P. Sopannarath, H. U. Graser, and S. Tumwasorn. 2008. Genetic parameters and annual trends for birth and weaning weights of a Northeastern Thai indigenous cattle line. Asian-Aust. J. Anim. Sci. 21(4):478-483.

Islam, M.S., A. Akhtar, M.A. Hussain, M.F. Rahman and S.S. Hossain. 2017. Reroductive performance and repeatability estimation of some traits of crossbred cows in Savar dairy farm. J. Environ. Sci. Nat. Res. 10: 87-94.

Kaswati, Sumadi and N. Ngadiyono. 2013. The heritability estimation of birth weight, weaning weight of Bali cattle at Balai Pembibitan Ternak Unggul Sapi Bali. Bul. Pet. 37: 74-78.

Mansur, M., A.T.B.A. Mahmud, M.I.A. Dagong, L. Rahim, Rr. S.R.A. Bugiwati and S. Baco. 2016. Genetic diversity of Bali cattle in Barru Regency based on phenotype characteristics and microsatelite DNA identifier. JITP . 4: 105-113.

M'Hamdi, N., R. Aloulu, S.K. Brar, M. Bouallegue and M.B. Hamouda. 2011. Phenotypic and genetic parameters of reproductive traits in Tunisian Holstein cows. Rev. Cient. UDO. Agric. 11: 167-173.

Montaldo, H.H., C. Trejo and C. Lizana. 2017. Genetic parameters for milk yield and reproduction traits in the Chilean Dairy Overo Colorado cattle breed. Cien. Inv. Agric. 44(1): 24-34.

Mustafa, M. I., M. K. Bashir, A. Yousaif and B. Ahmad. 2002. Repeatability estimates of some productive and reproductive traits in Red Sindhi cattle. Pakistan Vet. J. 22(3): 120-123.

Nandolo, W. 2015. The performance of Jersey cattle at Naming’omba tea and coffee estate in Malawi. Livest. Res. Rur. Dev. 27(1).

Neser, F.W.C., J.B. van Wyk, M.D. Fair, P. Lubout and B.J. Crook. 2012. Estimation of genetic parameters of growth traits in Brangus cattle. S. Afr. J. Anim. Sci. 42(1): 469-473.

Oyama, K., T. Katsuta, K. Anada and F. Mukai. 2002. Heritability and repeatability estimates for reproductive traits of Japanese Black cows. Asian-Aust. J. Anim. Sci. 15: 1680-1685.

Peayun, T.G.O., S. Putra and W. Puger. 2014. Reproduction performance of Bali cattle on three strata system. JKH. 8(1): 61-63.

Prasojio, G., I. Arifiantini and K. Mohamad. 2010. The correlation between the gestation period, birth weight, and new born calves sex after artificial insemination of Bali cattle. J. Veteriner. 11(1): 41-45.

Priyanto, R., H. Nuraini, Muladno, M. Ismail and H. Wijayanto. Slaughter, carcass and non-carcass characteristics of local cattle and buffalo in Indonesia. Pak. J. Ntr. 18:117-124.

Putra, W.B.P., Sumadi and T. Hartatik. 2014. Estimation of breeding value and most probable producing ability of production traits Aceh cattle at Indrapuri District Aceh Province. Bulet. Pet. 38(1): 1-7.

Putra, W.P.B.P., Sumadi, T. Hartatik and H. Saumar. 2015. Evaluation of growth traits of Aceh cattle in Indrapuri District of Indonesia. Bang. J. Anim. Sci. 44(2): 85-91.

Rahbar, R., M. Aminafshar, R. Abdullahpour and M. Chamani. 2016. Genetic analysis of fertility traits of Holstein dairy cattle in warm and temperate climate. Acta Sci. 38(3): 333-340.

Rahman, S.M.A., M.S.A. Bhuiyan and A.K.F.H. Bhuiyan. 2015. Effects of genetic and non-genetic factors on growth traits of high yielding dairy seed calves and genetic parameter estimates. J. Adv. Vet. Anim. Res. 2(4):450-457.

Rakwadi, E., S.J. Nsoso, T.N. Gondwe and J.W. Banda. 2014. Estimates of phenotypic and genetic parameters and responses to selection in growth traits in three beef cattle breeds raised under ranch conditions in Botswana. Bots. J. Agric. Appl. Sci. 11(1):2-10.

Regatieri, L.C., A.A. Boligon, F. Baldi and L.G. Albuquerque. 2012. Genetic correlations between mature cow weight and productive and reproductive traits in Nellore cattle. Genet. Mol. Res. 11(3):2979-2986.

Said, S., P.P. Agung, W.P.B. Putra, S. Anwar, A.S. Wulandari and A. Sudiro. 2016. Estimation of most probable producing ability for calf
birth’s performance in Sumba Ongole cows. J. Indonesian Trop. Anim. Agric. 41(2):53-60.

Samberi, K.Y., N. Ngadiyono and Sumadi. 2010. Estimation of the dynamics of population and productivity of Bali cattle in Kepulauan Yapen Regency, Papua Province. Buletin Peternakan. 34(3):169-177.

Sari, E.M., M.A. Nashri and C. Hasnani. 2016. Heritability estimation of quantitative traits in Aceh cattle. Agripet. 16(1):37-41.

Setiyabudi, R.J.W., Muladno, and R. Priyanto. 2016. Estimation of genetic parameters for growth traits of Bali cattle in breeding center of Bali cattle. JIPTHP. 4(3):327-333.

Silva, L.N., E. Gasparino, R.A.A.T. Junior, K.E. Filho, L.O.C. Silva, M.M. Alencar, M.D.S. Junior, J.V.F. Battistelli and S.C.C. Silva. 2015. Repeatability and genotypic correlations of reproductive and productive traits of crossbred beef cattle dams. Genet. Mol. Res. 14(2):5310-5319.

Sivarajasingam, S. 1975. Repeatability of reproductive traits among Kedah-Kelantan cattle. MARDI Res. Bull. 4:102-104.

Singh, R.R., T. Dutt, A. Kumar and M. Singh. 2010. Estimation of direct genetic additive and maternal variance for growth traits in Vrindavani cattle. J. Appl. Anim. Res. 38(1):145-148.

Siswanto, M., N.W. Patmawati, N.N. Trinayani, I.N. Wandia and I.K. Puja. 2013. Reproductive performance of Bali cattle under intensive management system in breeding instalation of Pulukan. JIKH. 1(1):11-15.

Soekardono, C. Arman and L.M. Kasip. 2009. Grade identification and reproductive coefficient of Bali cattle breeding female in West Nusa Tenggara Province. Bulet. Pet. 33(2):74-80.

Steel, R.G.D. and J.H. Torrie. 1980. Principles and Procedures of Statistics. 2nd ed. McGraw-Hill, New York.

Susanti, A.E., N. Ngadiyono and Sumadi. 2015. Output estimation of beef cattle in Banyuasin Regency of South Sumatera Province. J. Pet. Srijaya. 4: 17-28.

Tavares, L., E. Baliarti and S. Bintara. 2012. Preweaning growth of Bali calves at Balai Pembibitan Ternak Unggul Sapi Bali. Bulet. Pet. 36(3): 66-74.

Tribudi, Y.A. and P.W. Prihandini. 2019. Repeatability estimates for birth, weaning, and yearling weight in Madura cattle. IRJAES. 4(1):207-208.

Vostry, L., M. Milerski, E. Krupa, Z. Vesela, and H. Vostra-Vydrova. 2015. Genetic relationships among calving ease, birth weight and perinatal calf survival in Charolais cattle. Anim. Sci. Pap. Rep. 33(3):233-242.

Warwick, E. J., J. M. Astuti, and W. Hardjosubroto. 1990. Pemuliaan Ternak. Gadjah Mada University Press, Yogyakarta.