Genetic parameters on Bali cattle progeny test population

A R Hariansyah¹, A Raharjo¹, A Zainuri¹, Y Parwoto², D Prasetyo², S Prastowo¹, N Widyas¹
¹ Animal Science Department, Faculty of Agriculture, Universitas Sebelas Maret, Surakarta Indonesia
² Bali Cattle Breeding Center Pulukan, Indonesia

e-mail: nwidyas@gmail.com

Abstract. Bali cattle (Bos javanicus) is Indonesian indigenous cattle with having superior genetics potential on fitness traits in tropical environment and low feed quality. Bali Cattle Breeding Center Pulukan Indonesia conducted progeny test per annum in order to select bulls using offspring’s phenotype. This paper aimed to estimate the genetic parameters of yearling weight in Bali cattle progeny test populations and to observe the variation between periods in the above breeding center. Data were collected from the year of 2013 to 2014. There were four bulls (3 tests, 1 AI control) in 2013 and five bulls (4 tests, 1 AI) in 2014. Thirty breeding females were allocated per paddock per bull and allowed to mate naturally. In total 80 and 104 offspring’s records were obtained from 2013 and 2014 data, respectively. We built half-sib family model to estimate the additive genetic variance due to the sire and later estimate the breeding value (EBV) of each sire. Results showed that in 2013 the heritability (h²) for yearling weight was 0.19 while in 2014 was 0.79. In both years, tested bulls had higher EBV compared to the control bulls. The remarkable difference of heritability between years was due to the variations among bull candidates which might differ every year with regards to their origins. The fact that the EBV of tested bulls were higher than the control bulls gave us insight that despite the conservation policy and the continuous departure of Bali cattle bulls outside the Island, the population could still maintain its genetic quality.

1. Introduction
Bali cattle (Bos javanicus) is Indonesian indigenous cattle that was domesticated in Bali Island. Bali cattle widely spread over the Indonesian region, however its developed in eastern part of Indonesia such as South Sulawesi, West and East Nusa Tenggara, Central Sulawesi, South Kalimantan and West Kalimantan [1]. This cattle is highly adaptable and robust towards low feed quality [2], high fertility, good reproduction ability and excellent carcass quality [3]. Compared to exotic breed, Bali cattle has smaller body weight, 211-484 kg when mature [1,3], and slow growth rate [3].

Improving Bali cattle productivity can be done by improving feed quality [4–6], rearing management [6] and genetic quality by crossbreeding. In crossbreeding method, careful management is a must to avoid the decrease of Bali cattle genetic quality [5]. A best way to improve genetic quality is through male selection then applied in breeding program, this expected to enhance productive traits of Bali Cattle [7].

Currently, Indonesian government running Bali cattle breeding facilities in Bali which perform selection program using its phenotype offspring call progeny test. The program will result estimate breeding value (EBV) of specific parents, particularly male, which relatively have better performance
compared to the population average. Doing selection by phenotypic trait should pay attention in the $h^2$ of the trait. In this regard $h^2$ defined as a degree of specific trait that inherited from parent to its offspring [8]. Higher $h^2$ represent strong resemblance between parent and offspring [9] as well as in the contrary. Those two values, $h^2$ and EBV, named as genetic parameters are important value to guide the selection program. For that, this paper aimed to estimate the genetic parameters of Bali cattle in Bali Cattle Breeding Center Pulukan Indonesia. We will use weaning weight (WW) and yearling weight (YW) data from offspring during progeny test program for data analysis.

2. Methods

2.1 Data

Data were collected from Bali Cattle Breeding Center Pulukan Indonesia. The data consists of YW records in 2013 and 2014. Tested bulls (n = 7) were mated naturally with female and 2 AI bulls we used as control bulls. Each bull was mated with 30 cows in every paddock. Yearling weight were adjusted to 365-day of age using the following formula:

$$YW_A = \left( \frac{YW_{WW}}{\text{rearing period (days)}} \times 160 + WW_A \right)$$

$YW_A$ = adjusted yearling weight (365 days)
$YW$ = actual yearling weight
$WW$ = weaning weight
$WW_A$ = adjusted weaning weight (205) [10]

2.2 Estimation of heritability

A linear model was built to calculate $h^2$ of YW as follows:

$$y_{ijk} = \mu + \text{sex}_i + S_{ij} + e_{ijk}$$

$y_{ijk}$ = performance of individual
$\mu$ = mean
$\text{sex}_i$ = sex of the offspring
$S_{ij}$ = sire
$e_{ijk}$ = error

Followed with analysis of variance and separation of variance components as presented in Table 1

| Table 1. Analysis of variance and separation of variance components |
|---------------------------------------------------------------|
| Source          | DF$^1$ | SS$^2$ | MS$^3$ |
| Sire           | s-1    | SSs$^4$ | EMSs$^5$ |
| Offspring      | n-s    | SSp$^6$ | KTw |
| Total          | n-1    | JKt    |

Note:
1 degree of freedom
2 sum of square
3 means of square
4 sum of square sire
5 expected means square
6 sum of square progeny-sire [11]
Following the variance analysis, $h^2$ value was calculated using the following formula:

$$h^2 = \frac{4 \times \sigma^2}{\sigma^2 + \sigma_e^2}$$

Where:

- $\sigma^2_s$ = additive sire
- $h^2$ = heritability
- $\sigma^2_e$ = error

[12]

2.3 Estimated of Breeding Value

The calculation of bulls breeding value was based on the performance of his half-sib family according to the following formula:

$$EBV = \frac{1}{1 + (n-1)h^2} (\bar{P}_{\text{offspring}} - \bar{P}_{\text{population}})$$

Where:

- $EBV$ = estimated breeding value
- $\bar{P}_{\text{offspring}}$ = mean of the offspring
- $\bar{P}_{\text{population}}$ = mean of population
- $h^2$ = heritability
- $n$ = offspring number

3. Results and Discussion

The $h^2$ of YW in Bali cattle at 2013 and 2014 were 0.14 and 0.79, respectively (Table 2). In 2014 YW $h^2$ was higher compared to 2013, this represent genetic improvement means a success of selection program [13]. High $h^2$ indicate large number of genetic variants are inherited by the parent to offspring [16]. Moreover, the value of $h^2$ will vary in different population [17].

| Year | Heritability | $\sigma^2_s$ | $\sigma^2_e$ |
|------|-------------|-------------|-------------|
| 2013 | 0.19        | 194.7       | 82.2        |
| 2014 | 0.79        | 16.5        | 21.25       |

Table 2. Heritability value of yearling weight

Estimated breeding value is defined as relative value based on position in the population, according to the performance derived from its offspring. High EBV means more genetic factors will affect offspring’s performance. Therefore, EBV can be used as reference in the selection program. Results shows different EBV of YW in different bulls in every year of progeny test program (Figure 1). We can see positive and negative value of EBV, negative means that the bull has EBV below the population’s average [16].
To select bull for breeding program, bulls can be ranked according to his EBV value. Bulls with positive EBV may select as elite bulls for genetic improvement of specific trait in the next generation [17]. As explained in the previous report, it is still rooms to improve Bali cattle genetic quality through selection process [18], following carefully consideration to use that genetic potential for pure or crossbred purposes [19].

4. Conclusions
According to the result of $h^2$ and EBV in this paper, we show that there is variation of bulls in Bali Cattle Breeding Centre Pulukan Indonesia. It is giving us an insight that the population could still maintain its genetic quality. A sustainable selection process must be considered well to improve specific trait in Bali Cattle, while keeping its variation for future generation.

Acknowledgment
This study was funded by the Maintenance Research Group Grant, Ruminant Animal Research Group, Provided by Universitas Sebelas Maret Surakarta Indonesia at fiscal year 2017.

References
[1] Talib C, Entwistle K, Siregar A, Budiarti-Tunner S and Lindsay D 2002 Survey of Population and Production Dynamics of Bali Cattle and Existing Breeding Programs in Indonesia Strategies to Improve Bali Cattle in Eastern Indonesia ed K Entwistle dan D R Lindsay (Australian Centre for International Agricultural Research) Pages 3–9
[2] Copland J 1997 Bali Cattle: Origins in Indonesia Jembrana Disease and the Bovine Lentivirus ed G E Wilcox, S Soeharsono, D M N Dharma and J W Copland (Australian Centre for International Agricultural Research) Pages 29–33
[3] Wiryosuhanto S 1997 Bali Cattle–Their Economic Importance in Indonesia Jembrana Disease and the Bovine Lentivirus ed G E Wilcox, S Soeharsono, D M N Dharma and J W Copland (Australian Centre for International Agricultural Research) Pages 34–42
[4] Oka L 2002 Performance of Bali Cattle Heifers and Calves prior to Weaning Weight n a Feedlot System Strategies to Improve Bali Cattle in Eastern Indonesia ed K Entwistle dan D R Lindsay (Australian Centre for International Agricultural Research) Pages 14–16
[5] Mastika I M 2002 Feeding Strategies to Improve the Production Performance and Meat Quality of Bali Cattle (Bos sondaicus) Strategies to Improve Bali Cattle in Eastern Indonesia ed K Entwistle dan D R Lindsay (Australian Centre for International Agricultural Research) Pages 10–13
[6] Bamualim A and Wirdahayati R B 2002 Nutrition and Management Strategies to Improve Bali Cattle Productivity in Nusa Tenggara Strategies to Improve Bali Cattle in Eastern Indonesia
ed K Entwistle dan D R Lindsay (Australian Centre for International Agricultural Research)
Pages 17–22
[7] Miller S 2010 Genetic improvement of beef cattle through opportunities in genomics Rev. Bras. Zootec. 39 247–255
[8] Cassel B 2009 Using Heritability for Genetic Improvement Virginia Cooperative Extension 404-084 1–4
[9] Wray N R and Visscher P M 2008 Estimating trait heritability Nature Education 1 1–4
[10] Warwick E J, Astuti J M and Hardjosubroto W 1990 Pemulian Ternak (Yogyakarta: Gadjah Mada Univ. Press)
[11] Hardjosubroto W 1994 Aplikasi Pemuliaan Ternak di Lapangan (Jakarta: Gramedia Widiasarana Indonesia)
[12] Nagy I 2011 Quantitative genetics (Kaposvár University)
[13] Kaswati, Sumadi and Ngadiyono N 2013 Estimasi nilai heritabilitas berat lahir, sapih, dan umur satu tahun pada sapi bali di balai pemibitan ternak unggul sapi bali Bul. Pet. 37 74–8
[14] Falconer D S and Mackay T F C 1996 Introduction to Quantitative Genetics (London: Longman Group Ltd)
[15] Fuerst C 2012 Effect of inbreeding depression on survival of Austrian Brown Swiss calves and heifers J. Dairy Sci. 95 6086–92
[16] Hardjosubroto W 1994 Aplikasi Pemuliaan Ternak di Lapangan (Jakarta: Gramedia Widiasarana Indonesia)
[17] Goddard M G and Smith C 1990 Optimum number of bull sires in dairy cattle breeding J. Dairy Sci. 73 1113–22
[18] Widyas N, Nugroho T and Prastowo S 2017 Rooms for genetic improvement in Indonesian Bali cattle population. IOP Conference Series: Materials Science and Engineering 193 12037
[19] Prastowo S, Widi T and Widyas N 2017 Preliminary analysis on hybrid vigor in Indonesian indigenous and crossbred cattle population using data from published studies. IOP Conference Series: Materials Science and Engineering 193 12028