ISSN: 0852-3681
E-ISSN: 2443-0765

Jurnal Ilmu-Ilmu Peternakan 32(3): 398 – 406
Available online at http://jiip.ub.ac.id

A Predicted Genetic Parameter for Body Weight and Body Size at Yearling Age of Male Bali cattle

Meidina Chaerunissa[1)] and V.M. Ani Nurgiartiningsih*[2)]

[1)]Student of Animal Science Faculty, Universitas Brawijaya
[2)]Lecturer of Animal Science Faculty, Universitas Brawijaya

Submitted: 29 August 2022, Accepted: 6 December 2022

ABSTRACT: This research aimed to predicted the genetic parameter for body weight and body size, including body height, body length, and chest girth at yearling age of male Bali cattle in BPTU-HPT Denpasar, Bali. The materials used were 79 heads of male Bali at yearling age. The variables observed were body weight (BW), body height (BH), body length (BL), and chest girth (CG) recorded from 2016 to 2018. The body weight and body size data were analyzed to find out the mean, standard deviation, and coefficient of variation. Variance and co variance component were analyzed using Analyses of Variance and Covariance one way lay out un balanced design. The heritability and genetic correlation were calculated using the paternal half-sib correlation method. Results showed that the average of body weight, body height, body length, and chest girth were 129.72±13.73 kg, 102.91±4.27 cm, 94.32±5.54 cm, and 121.91±8.47 cm, respectively. The value of heritability estimation for body weight, body height, body length, and chest girth were 0.50±0.08, 0.46±0.07, 0.44±0.07, and 0.10±0.02, respectively. The genetic correlation between BW-BH, BW-BL, and BW-CG were categorized as moderate to a high value (0.67, 0.98, and 0.35, respectively). Breeding value for body weight and body height were both 50% positive value, and breeding value for body length and chest girth were 40% and 60% positive value, respectively. The rank correlation coefficient between rank based on BW-BH, BW-BL, and BW-CG were 0.31, 0.61, and -0.01, respectively. Based on the heritability value, genetic correlation, and rank correlation coefficient, body length could be used as selection criteria, which would give a response to improve body weight.

Keywords: Heritability; Breeding value; Genetic correlation; Body height; Body length; Chest girth

*Corresponding Author: vm_ani@ub.a

INTRODUCTION

In Indonesia, Bali cattle is one of the important indigenous cattle breeds contributing to the development of livestock industries and spread widely throughout Indonesia, especially in South Sulawesi, Bali, East and West Nusa Tenggara, Southeast Sulawesi and Lampung. This breed has unique traits such as being well adapted to tropical climate with high temperature, has a capability to utilize low quality feed, high fertility rate (83%), and good carcass percentage (56%) (Payne and Hodges, 1997). The coat color of Bali cattle is unique, reddish-brown, except for the white area on the hindquarter that extends along their belly, and also white socks reaching from the hooves to the hocks. In bulls, the red hair of the whole body turns to black by the time of maturity.

A performance tests is a preliminary selection method in Bali cattle based on qualitative and quantitative traits, including measuring, weighing, and observation. Performance test in Bali cattle are conducted at the age of 205 days, 365 days, and 550 days. On that stage, male Bali cattle just starting the early stage of optimal growth before reach the sexual maturity, so the overview of the prospective bull with high productivity can be obtained (Patmawati, Trinayani, Siswanto, Wandia, and Puja, 2013).

Heritability is the most important consideration in determining appropriate animal evaluation methods, selection methods, and mating systems. Heritability is a concept that summarizes how much of the variation in a trait is due to variation in genetic factors (Wray and Visscher, 2008). The numerical value of heritability estimation ranges between 0 (no genetic contribution) and 1 (all differences on traits reflect genetic variation)

Heritability is used to predict the breeding value, and it is important to develop a selection program and mating plan for increasing animal superiority. Breeding value is a genetic superiority of an individual for a certain trait based on its position in a population. This value represents the genetic superiority from the livestock that is selected as a parent for the next generation compared by the average of all livestock on its population (Nurgiartiningsih, 2017).

Some traits are genetically correlated, and the correlation may be positive or negative. Genetic correlation occurs when a single gene affects two traits. Positive correlation between two or more traits can make the selection more efficient because selection based on one trait will be followed by an increase in one trait and related trait. If there is no genetic correlation between expected traits, the selection will be ineffective (Sudarmadji, Mardjono, and Sudarmo, 2007). According to the statement above, this research was conducted to support the genetic improvement of the male Bali cattle breeding program in BPTU-HPT Denpasar applying the heritability, genetic correlation, and breeding value for important traits at yearling age.

MATERIALS AND METHODS

This study was carried out in BPTU-HPT Denpasar located in Pangyangan village, Pekutatan district, Jembrana, Bali, and this study conducted from February to March 2020.

The materials used in this study were 79 heads of male Bali cattle, offspring of 10 sires, which are mated to 79 dams. The number of dam which are mated to the sire are not the same, ranged from 4 to 19 dams/sire. Data used in this research were body weight (BW), body height (BH), body length (BL), and chest girth (CG) at yearling age that has been corrected by BPTU-HPT Denpasar, which collected in 2016 to 2018.

The heritability and genetic correlation were calculated using the paternal half-sib correlation method. The data of half-sib group were analyzed using a statistical models according to Nurgiartiningsih (2017):

$$Y_{ij} = \mu + s_i + e_{ij}$$

Where:
Y_{ij} = Observation on the j-th individual on the sire i-th
μ = Population mean
s_i = Effect of sire i
e_{ij} = Deviation of the uncontrolled environmental and genetic on each individual

The component of variation between and within sire were analyzed using analyses of variance (ANOVA) on Table 1.

Table 1. Analyses of variance for half-sib method

Source of variance	df	SS	MS	EMS
Between sire	$s-1$	SS_s	MS_S	$\sigma_w^2 + n\sigma_s^2$
Within sire	$s(n-1)$	SS_w	MS_W	σ_w^2
Total	$ns-1$	SS_t		

Where:
s = Total sire
n = Total offspring each sire
σ_s^2 = Variance between sire
σ_w^2 = Variance within sire
SS = Sum of square
df = Degree of freedom
MS = Mean square
EMS = Expected mean square

The number of offspring per sire are not the same. Therefore n was replaced with k which calculated using formula below:

$$k = \frac{1}{s-1} n. - \sum \frac{n_i^2}{n.}$$

Estimation of Variance Components were:

$$\sigma^2 w = MS_w$$
$$\sigma^2 \mathrm{s} = \frac{MS_s - MS_w}{\mathrm{k}}$$

Correlation of intra-class (t) is a similarity measurement between half-sib determined by:

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

Heritability value (h^2) predictedd using paternal half-sib correlation method according to Hardjosubroto (1994) as follows:

$$h^2 = 4t$$

$$h^2 = \frac{4(\sigma_s^2)}{\sigma_s^2 + \sigma_w^2}$$

Standard Error (SE) of heritability value was calculated according to Nurgiartiningsih (2017):

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

Genetic correlation is calculated using the following formula of Nurgiartiningsih (2017):

$$r_g = \frac{\text{Cov s}}{\sqrt{\sigma_{g1}^2 \sigma_{g2}^2}}$$

Where:
r_g = Genetic Correlation
Cov s = Covariance of two traits between sire
σ_{g1}^2 = Variance of sire for the first trait
σ_{g2}^2 = Variance of sire for the second trait

Breeding value is calculated based on a single measurement. The formula of relative breeding value was based on Nurgiartiningsih (2017) as follows:

$$EBV = h^2 (P - \bar{P})$$

Where:
EBV = Estimation of breeding value
h^2 = Heritability value
P = Individual performance
$\bar{P}$ = Mean of population performance in the same individual group

The rank correlation coefficient is calculated using the Spearman correlation coefficient method. The Spearman correlation coefficient is defined as the Pearson coefficient between rank variables. The formula was according to Kendall (1970) as follows:

$$r_s = 1 - \frac{6\sum d_i^2}{n(n^2-1)}$$

Where:
r_s = Rank correlation coefficient
d_i = The different between two ranks of each observation
n= The number of observations

RESULT AND DISCUSSION

Body weight and body size of Bali Cattle

The mean of body weight (BW) is 129.72±13.73 kg with a range from 99 to 158.5 kg, body height (BH) is 102.91±4.27 cm with a range from 89 to 113 cm, body length (BL) is 94.32±5.54 cm with a range from 82 to 106 cm, and the mean of chest girth (CG) is 121.91±8.47 cm with data range from 96 to 145 cm. Setiaji, Prastowo, Prasetiyo, and Widyas (2019) reported the mean of yearling weight of Bali cattle in BPTU-HPT Denpasar between 2013 to 2016, was 122.46±18.29 kg.

This previous research was lower than the result of this study, which could be explained that there was an improvement of performance in Bali cattle due to selection applied in BPTU-HPT Denpasar. Baiduri et al. (2012) reported that means for body length, body height, and chest girth on yearling age of Bali cattle were 95.9±4.46 cm, 100.28±4.35 cm, and 125.45±7.40 cm, respectively. Means of body length and chest girth in this research were slightly lower than the previous study. However, the mean of body height in this research was slightly higher than the previous study. The factor that influences the differences between previous research is genetic factor and also management factor.

The management has covered some points such as feed, infrastructure, and environmental management. Environmental and feed supply can directly influence the body performance (Kaswati et al., 2013). Good management since the birth age will gives good and rapid growth with a high value of body measurement.

Table 2. Mean of body weight, body height, body length and chest girth of Bali cattle

Sex	Parameter	N	Mean	SD	CV (%)
Male	Body Weight (kg)	79	129.72	13.73	10.58
	Body Height (cm)	79	102.91	4.27	4.19
	Body Length (cm)	79	94.32	5.54	5.87
	Chest Girth (cm)	79	121.91	8.47	6.95

Heritability

Heritability values for body weight (BW), body height (BH), and body length (BL) are 0.50±0.08, 0.46±0.07, 0.44±0.07, respectively, and categorized as a high value. Otherwise, the heritability value of chest girth (CG) has a low value (0.10±0.02). According to Hardjosubroto (1994), heritability value is categorized into 3 groups, and there are <0.15 (Low). 0.15-0.3 (Moderate) and > 0.3 (High).

The highest value of heritability in this research was on body weight. Heritability value of body weight is 0.50±0.08, which means the differences of body weight between individual cattle in the population is 50% caused by additive genetics factor and the rest of it caused by environmental factor. Heritability for body weight in this research was higher than the value obtained by Setiaji et al. (2019), in the same place (BPTU-HPT Denpasar), based on data from 2013 to 2016 which was 0.39±0.15. The different observation time and the different methods used may cause the differences between heritability values (Lasley, 1978). It means, there is a genetic improvement on Bali cattle in BPTU-HPT Denpasar.

The heritability for body height and body length were 0.46±0.07 and 0.44±0.07, respectively. Heritability for body height and body length in this research were lower than previous research done by Baiduri et al. (2012) which were 0.85±0.002 and 0.56±0.001 for body length and body height of Bali cattle in BPTU-HPT Denpasar which collected in 2006 to 2010. The different observation time and different population will cause a differences in heritability value obtained due to changes in livestock composition and genetic variation in the population (Kaswati et al., 2013)

The lowest value of heritability in this research was on chest girth. Heritability value for chest girth (CG) was 0.10±0.02. Baiduri et al. (2012) reported that the heritability value for chest girth at yearling age of Bali cattle was 0.44±0.0009 which means higher compared to the result of this research. Several environments can cause an expression of genetic differences to be greater and it increases the genetic variation (Warwick, Astuti, and Hardjosubroto, 1990). Management also can affect the heritability value. Therefore, the management procedures are carried out to the maximum extend for an increasing the heritability value

The standard error (SE) for heritability of body weight and body size (Body height, body length and chest girth) are categorized low. It means the heritability value is reliable and proper to be applied for genetic improvement of Bali cattle.

Table 3. Heritability value and standard error for body weight, body height, body length, and chest girth of Bali cattle.

Variable	N	h^2	SE
Body Weight (kg)	79	0.50	0.08
Body Height (cm)	79	0.46	0.07
Body Length (cm)	79	0.44	0.07
Chest Girth (cm)	79	0.10	0.02

Genetic correlation

The Genetic correlations of this study were categorized as moderate to high value. Genetic correlation between BW-BH, BW-BL and BW-CG were 0.67, 0.98 and 0.35, respectively. According to Warwick et al. (1990), coefficients of genetic correlation are divided into three categories, there are high (>0.50-1.00); moderate (>0.25-0.50) and low (>0.05-0.25).

The genetic correlation between BW-BH was categorized as a high positive value (0.67), it means the correlation between BW-BH is 67% affected by genetic factors and 33% remains caused by the other factors. This value means that selection of parent based on BH will also give response on increasing of BW of the offspring. According to genetic correlation value, coefficient of determination can be determined by squaring the genetic correlation value.

The coefficient of determination for BW-BH was 0.45, which means the body weight of Bali cattle at yearling age was 45% influenced by body height. Gunawan and Jakaria (2007) reported that the correlation between BW-BH was 0.78 which is categorized as a highly genetically positive correlation. The genetic correlation in this research was slightly lower than the previous study. The genetic correlation value between BW-BL was 0.98, thus it was categorized as a high positive value. Genetic correlation value on this research was higher compared to Gunawan and Jakaria (2007), the correlation between BW-BL was 0.78. Furthermore, the genetic correlation between BW-CG is categorized as a moderate positive value (0.35), meaning that increasing of CG will also increase moderately of BW.

The result in this research has a lower value compared to previous study done by Gunawan and Jakaria (2007) with the genetic correlation between BW-CG was 0.87. Different methods used while observation can obtain a different value of genetic correlation, because each method has a different ability to eliminate the non-additive genetic variation from additive genetic variation. According to Sulastri and Hamdani (2018), factors that influence the genetic correlation are breeding systems that are applied in population, data structure, and estimation method.

Table 4. Genetic correlation between body weight-body height, body weight-body length, body weight-chest girth of Bali cattle

Variable	N	Genetic Correlation	Coefficient of Determination (%)
BW-BH	79	0.67	45%
BW-BL	79	0.98	96%
BW-CG	79	0.35	12%

Breeding value

According to the result of this study, from 10 evaluated sires, the positive breeding value on body weight was 5 sires or 50% of total sire. The mean of body weight which has a positive breeding value was 134.44 kg. There were also 5 sires with positive breeding value for body height with the mean of body height was 103.55 cm. Positive breeding value for body length was 4 sires with the mean of body length was 96.93 cm.

Furthermore, the positive breeding value for chest girth was 6 sires or 60% of total sire with the mean chest girth was 123.72 cm. Sire with a positive breeding value showed that the trait was above the population mean. Prihandini et al. (2012) reported that a higher breeding value of the sire shows the superiority of the sire which is expected to be inherited by its superiority to the offspring.

The sire with the number Bedugul11293MM287 showed the highest relative breeding value for body weight (5.78 kg), which means that body weight mean of offspring is 5.78 kg above the population mean. Meanwhile, the breeding value of Bedugul11293MM287 for body height and body length were 0.88 and 1.55, it means superiority of the Bedugul11293MM287 offspring on body height and body length is relatively 0.88 cm and 1.55 cm, respectively above the population mean. However, the breeding value of Bedugul11293MM287 for chest girth was -0.02 which means the superiority of the Bedugul11293MM287 offspring on chest girth is relatively 0.02 below the average of the population.

Table 5. Breeding value of body weight, body height, body length, and chest girth of Bali cattle at yearling age.

No.	Sire	Body Weight		Body Height		Body Length		Chest Girth	
		R	BV	R	BV	R	BV	R	BV
1	Bedugul11293MM287	1	5.78	3	0.88	1	1.55	7	-0.02
2	0554.12	2	2.12	8	-0.72	8	-1.24	1	0.53
3	0132.13	3	2.09	2	1.08	2	1.43	9	-0.31
4	0111.13	4	1.35	7	-0.08	4	0.44	4	0.08
5	0537.10	5	0.23	4	0.43	6	-0.26	5	0.06
6	0102.13	6	-1.21	5	0.04	5	-0.14	10	-0.84
7	0538.10	7	-1.46	9	-0.82	7	-0.29	2	0.26
8	0137.13	8	-2.64	1	1.29	3	1.18	8	-0.30
9	0106.13	9	-6.55	6	-0.07	9	-1.46	3	0.16
10	IB (0102.10)	10	-8.44	10	-2.69	10	-3.00	6	0.01

The rank correlation coefficient measures the degree of similarity between two rankings and can be used to assess the significance of the relation between them. Their magnitude increases as the association increases with a +1 value when there is a perfect association from the concordance of all pairs, while -1 value when there is a perfect negative association from the discordance of all pairs (Tarsitano, 2009).

DOI: 10.21776/ub.jiip.2022.032.03.11

Table 6. Rank correlation between rank of body weight-body height, body weight-body length, body weight-chest girth.

Variable	N	Rank Correlation Coefficient (r_s)
BW-BH	10	0.31
BW-BL	10	0.61
BW-CG	10	-0.01

Schober, Boer, and Schwarte (2018) stated that rank correlation (r_s) value interpretations should be given to avoid misunderstanding when reporting correlation coefficients and their strength. There are 5 categories of r_s strength, 0.00-0.10 (Negligible correlation), 0.10-0.39 (Weak correlation), 0.40-0.69 (Moderate correlation), 0.70-0.89 (Strong correlation), 0.90-1.00 (Very strong correlation). According to the result of the rank correlation coefficient of this research, the rank correlation coefficient between the rank of breeding value based on body weight and rank based on body height has a weak relation (0.31). There is a moderate relation between rank based on body weight and rank based on body length (0.61). Furthermore, rank correlation coefficient between rank of breeding value based on body weight and rank based on chest girth has a negative value and it is categorized as a weak relation (-0.01). Based on the magnitude of the rank correlation, the relation between two rankings of breeding value can be interpreted. The highest rank correlation coefficient was between the rank of breeding value based on body weight and rank of breeding value based on body length (0.61).

CONCLUSIONS

According to the result of this study, body length could be used as criteria for selection in male Bali cattle due to its high heritability value, its genetic correlation with body weight, and high rank of correlation with the rank of breeding value for body weight.

REFERENCES

Baiduri, A.A., Sumadi., and N. Ngadiyono. 2012. Pendugaan Nilai Heritabilitas Ukuran Tubuh Pada Umur Sapih Dan Umur Setahun Sapi Bali Di Balai Pembibitan Ternak Unggul Sapi Bali, Jembrana, Bali. Buletin Peternakan 36 (1): 1–4.

Gunawan, A., and Jakaria. 2007. Application of Linear Body Measurements for Predicting Weaning and Yearling Weight of Bali Cattle. Animal Production 12 (3): 163–68.

Hardjosubroto., W. 1994. Aplikasi Pemuliabiakan Ternak Di Lapangan. Jakarta: PT Gramedia Widiasarana Indonesia.

Kaswati., Sumadi., and N. Ngadiyono. 2013. Estimasi Nilai Heritabilitas Berat Lahir, Sapih, Dan Umur Satu Tahun Pada Sapi Bali Di Balai Pembibitan Ternak Unggul Sapi Bali. Buletin Peternakan 37 (2): 74–78.

Kendall, M. G. 1970. Rank Correlation Methods. London: Griffin.

Lasley, J. 1978. Genetics of Livestock Improvement 3rd Ed. 3rd ed. Eaglewood Cliff, New Jersey: Prentice-Hall Inc.

Nurgiartiningsih, A. 2017. Pengantar Parameter Genetik Pada Ternak. Malang: UB Press.

Patmawati, N.W., N.N Trinayani., M Siswanto., I.N Wandia., and I.K Puja. 2013. Seleksi Awal Pejantan Sapi Bali Berbasis Uji Performans. Jurnal Ilmu Dan Kesehatan Hewan 1 (1): 29–33.

Payne, W. J. A., and J. Hodges. 1997. Tropical Cattle: Origins, Breeds and Breeding Policies. Tropical Cattle: Origins, Breeds and Breeding Policies.

Prihandini, P.W., L. Hakim., and V.M.A. Nurgiartiningsih. 2012. Seleksi Pejantan Berdasarkan Nilai Pemuliaan

Pada Sapi Peranakan Ongole (Po) Di Loka Penelitian Sapi Potong Grati – Pasuruan. J. Ternak Tropika 13 (1): 918.

Schober, P., C. Boer., and L.A. Schwarte. 2018. Correlation Coefficients: Appropriate Use and Interpretation. Special Article 126 (5): 1763–68.

Setiaji, R., S. Prastowo., D. Prasetiyo., and N. Widyas. 2019. Phenotypic and Genetic Correlations of Growth Traits in Bali Cattle Breeding Population. IOP Conference Series: Earth and Environmental Science 372 (1): 0–6.

Sudarmadji., R. Mardjono., and H. Sudarmo. 2007. Variasi Genetik, Heritabilitas, Dan Korelasi Genotipik Sifat-Sifat. Jurnal Littri 13 (3): 88–92.

Sulastri, and Muhammad Dima Iqbal Hamdani. 2018. Dasar Pemulian Ternak. Lampung: AURA.

Tarsitano, A. 2009. Comparing the Effectiveness of Rank Correlation Statistics. Economica e Statistica 6 (n): 1–25.

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

Wray, N. R., and P.M. Visscher. 2008. Estimating Trait Heritability. Nature Education.