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Evaluation of breeding value based on body weight and body measurement at one day of age in Madura cattle

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ABSTRACT: The objective of this research was to evaluate the breeding value based on body weight and body measurement at one day of age in Madura cattle on the Technical Implementation Unit of Animal Breeding and Health East Java. Recording data used were withered height (WH), body length (BL), chest girth (CG), and birth weight (BW) that birth from 2014 until 2020. Analyzed variables consist of heritability, breeding value, and spearman correlation. The analysis result showed heritability for the performance of 1 day of age in Madura cattle categorized as a medium until high (0.33 – 0.64). Breeding value from 10 bull based on BW was 60% categorized positive. Meanwhile, breeding value based on WH, BL, CG was 40% categorized positive. The Spearman correlation of BW with WH and CG had a high correlation (0.73 and 0.78), while BW and BL had a low correlation (0.22). This research concluded that the highest breeding value of body weight and body measurement of Madura cattle at 1 day was sire Montahai/1661100. The genetic potency of Madura cattle should be improved by applying for a consistent breeding program with a sound recording and selection program.

Keywords: Breeding value; Heritability; Madura cattle; Spearman correlation

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INTRODUCTION

Madura cattle is one of the local cattle in Indonesia that has been through centuries of selection and domestication to achieve extraordinary diversity as of now (Widyas et al., 2018). Madura cattle is a crossbreeding of Zebu (*Bos Indicus*) with Bull (*Bos Javanicus*) (Nijman et al., 2003). Based on Decree of Minister of Agriculture Number 3755 / KPts / HK. 040 / 11 / 2010 on November 23rd, 2010, as a genetic resource of beef cattle in Indonesia, Madura cattle is one of the central government steps to protect and develop Madura cattle. The characteristics of Madura cattle were small body size, solid and short leg, yellowish-red hair color, white pattern on belly and thighs, and a typical horn and girth on their back (Nurgiartiningsih et al., 2016). The superiority of Madura cattle has had a tolerance to the low-quality forage, had a high percentage of the carcass with a good quality of meat and had high adaptability to the tropical area (Sutarno and Setyawan., 2015).

The measurement of body measurement and birth weight of Madura cattle is critical to be used as a benchmark on the growth potential of Madura cattle. Birth weight is one of the prenatal growth levels in cattle and reflects the growth potential of cattle for the next phase, like pre-weaning and post-weaning (Ashari et al., 2015). Bodyweight and body measurement at seven days of age in Madura cattle in four regencies (Bangkalan, Sampang, Pamekasan, and Sumenep) for BW (kg) were: 20.38 ± 3.21, 21. 24 ± 2.62, 22.75 ± 2.01 and 20.14 ± 4.48, CG (cm): 58.95 ± 9.84, 63.97 ± 6.86, 65.33 ± 4.44 and 75.55 ± 8.21, BL (cm): 54.77 ± 8.41, 51,03 ± 8.80, 59.00 ±5.75 and, 66.48 ± 6.89, WH(cm): 63.69 ± 7.77, 65.21 ± 6.54, 65.21 ± 3.09 and 72.55 ± 6.49 (Nurgiartiningsih., 2011).

The improvement of body measurement and bodyweight of Madura cattle can be reached with a selection program. One of the genetic parameters needed in the selection program is heritability value. Heritability is the inheritance value of a superior trait from parent to offspring. The illustration of selection progress can be seen from the level of heritability. The effective selection of economic traits was performed by higher parent heritability (Supriyantono et al., 2012). Heritability also can be used to estimate breeding value. Nurgiartiningsih. (2017) stated that breeding values illustrate individual superiority compared to the average total population. The higher heritability will increase the breeding value. Spearman correlation analysis based on breeding value rank was used in this research to know the correlation of birth weight with body measurement.

Previous research was reported by Trbudi et al. (2021) regarding the selection of sires based on the breeding value of the birth weight and weaning weight, but no one has used the breeding value and the spearman correlation of birth weight and body measurement simultaneously as an evaluation of the breeding value. Based on Madura cattle condition as one of the local cattle and genetic resources in Indonesia, this research was needed to carried out to evaluate breeding value rank based on body measurement and bodyweight to know the superior bull used as a benchmark of selection program to maintain the sustainability of pure Madura cattle in breeding center area on Madura Island.

MATERIALS AND METHODS

Place and Samples

This research was carried out in the Technical Implementation Unit of Animal Breeding and Health East Java, Jl. Raya Pamekasan – Sumenep Grujukan Village, Larangan Sub-district, Pamekasan Regency (first installation) and in Kalimo'ok Village, Kalianget Sub-district, Sumenep Regency (second installation). The number of samples was 166 heads of Madura cattle at one day of age (80 females and 86 males), offsprings of 16 sires of pure Madura cattle,

and birth from 2014 until 2020 were used in this study. Research data was used to know the effect of sex-to-body measurement on body weight. There was a reduction in the number of samples to 14 heads of 10 sires Madura cattle to estimate heritability, breeding value, and Spearman correlation based on breeding value. The observed variables in this research were body measurement (withers height, body length, and chest girth) and body weight at one day of age in Madura cattle.

Data Correction

In this research, body measurement and birth weight data of female Madura cattle were corrected to body measurement and birth weight of male Madura cattle, with the equation according to Hardjosubroto. (1994):

$$CH_{sex} = \frac{average\ of\ male\ body\ weight}{average\ of\ female\ body\ weight}$$

Data Analysis

Estimated the component of variance, heritability, breeding value, genetic correlation, and Spearman correlation based on breeding value were analyzed in the equation below.

Estimation of the component of variance was used to estimate the heritability using completely randomized design one-way ANOVA with the equation according to Hardjosubroto. (1994) and Nurgiartiningsih. (2017):

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

Information:

y_{ij} = observation on the *j*-th individual on the sire *i*-th

μ = population average

s_i = the effect of sire *i*-th

e_{ij} =deviations of the uncontrolled environmental and genetic effects on each individual

Heritability illustrates the superiority of the parent will be inherited to the offspring, estimated using half-sib correlation (Siremodel) with equation according to Hardjosubroto. (1994) and Nurgiariningsih. (2017):

$$h_s^2 = \frac{4\sigma_s^2}{\sigma_p^2} = \frac{4\sigma_s^2}{\sigma_s^2 + \sigma_w^2}$$

Information:

h^2 = heritability value

σ_s^2 = variance of sire

σ_w^2 = variance of within sire

Heritability is helpful to estimate breeding value (BV) on livestock traits. The breeding value uses to evaluate the genetic potential of livestock in a trait between its population. In this research, breeding value analysis is based on offspring test results with the equation according to Hardjosubroto. (1994) and Nurgiariningsih. (2017):

$$NP_{(PT)}\ \frac{2nh^2}{4+(n-1)h^2}\left(\bar{P} - \bar{\bar{P}}\right) + \bar{\bar{P}}$$

Informtion:

$NP_{(PT)}$ = Breeding value

$\bar{P}$ = Individual performance

$\bar{\bar{P}}$ = Average performance in population

h^2 = Heritability

Spearman correlation coefficient r_s *(rho)* was used to analyze the correlation between body weight and body measurement with equation (Trihendradi., 2009)

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

Information:

n = number of samples

D = Deviation of X and Y

6 = Constant Number

RESULT AND DISCUSSION

The Performance of Birth Weight and Body Measurement

The average body weight (BW), withers height (WH), body length (BL), and chest girth (CG) in Madura cattle can be seen in Table 1. The population of Madura cattle at one day of age in Technical

Implementation Unit of Animal Breeding and Health East Java birth from 2014 until 2020 were 166 head with the number of male 51.8 % (86 head) and female 48.2 % (80 head). In this research, Madura cattle had an average performance of birth weight 17 ± 2.43 kg for males and 16.09 ± 2.53 kg for females; based on this data, the birth weight of male Madura cattle was higher than the female. Prak et al. (2018) state that sex was one factor affecting the difference between growth and development of body measurement. The difference of body measurement with bodyweight on males and females was reported in F1 offspring from Charolais male and Simmental with body weight of male cattle being higher than female cattle (Bures dan Barton., 2012). Birth weight in this research was appropriate with the statement of Nurgiartiningsih et al. (2020) stating that the birth weight of male Madura cattle was 17.08 (2.40 kg and for females was 16.25 ± 2.37 kg. This research data was higher than Martojo's. (2012) data on Bali cattle which is 18.8 kg, and lower than Paputungan et al. (2015) on PO cattle (26.10 ± 1.55 kg). Meanwhile, it is lower than Friesian Holstein 33.90 ± 0.90 kg (Ozaka et al., 2013). The difference in body weight is caused by research location, genetic potential, and cattle breed. The benchmarks of livestock are judged by its ability to adapt to its environment (Hoffmann., 2010).

Table 1. The performance of total birth weight BW), withers height (WH), body length (BL), and chest girth (CG)

Parameter	Male		Female	
	n	Average ± SD	n	Average ± SD
Birth weight (kg)	86	17 ± 2.43	80	16.09 ± 2.53
Withers height (cm)	86	63.45 ± 4.52	80	60.64 ± 5.13
Body length (cm)	86	51.27 ± 4.90	80	50.78 ± 6.07
Chest gith (cm)	86	59.25 ± 402	80	57.39 ± 5.37

n = total of sample

Heritability of birth weight and body measurement of Madura cattle at one day is shown in Table 2. With 144 of the total sample, the reduction of the total sample in heritability analysis caused by males with total offspring ≥ 3 head was culled. The result of heritability estimation on birth weight, withers height, body length, and chest girth of Madura cattle at one day of age was categorized medium until high. Heritability of birth weight in this research was categorized as medium 0.33 ± 0.26 means that 33% of phenotypic variation of birth weight was influenced by genetic factors, and 67% were influenced by an environmental factor. A low value of heritability is caused by the decreasing feed quality given to the cattle that cause the decreasing of nutrient absorption and also caused by using the same male for years, affecting the decreasing of genetic variation (Ndofor- Foleng et al., 2012).

Heritability (h^2)

The estimation result of birth weight heritability in this research was appropriate with the statement from Nurgiartiningsih. (2017) that the value range of heritability in birth weight of beef cattle was 20 – 58%. Heritability of birth weight in this research was higher than the previous research reported by (Putra et al., 2015; Vostry et al., 2015; Rakwadi et al.; 2016; Regatieri et al., 2012) with 0.32 in Aceh cattle, 0.23 in Charolais cattle, 0.21 ± 0.11 in Tuli cattle and 0.28 ±0.02 in Nellore cattle. Meanwhile, lower than reported by (Aksakal et al., 2012; Afroz et al., 2011; Rakwadi et al.; 2016) with 0.59 ± 0.24 in Swedish Red and White Cattle, 0.50 ± 0.1 in Red Chittagong cattle, 0.57 ± 0.11 in Brahman cattle and 0.36 ± 0.08 in Bosmara cattle. This difference can be caused by the total sample, cattle breed, and different research times. Bayleto et al. (2010) state that calculation time and different populations caused the difference

in heritability value because there are changes in cattle composition and genetic variance in the population. SE value in this research was lower than heritability value, and it can be used as an accurate h^2 estimation.

Table 2. Heritability (h^2) and Standart Error (SE) of Body Weight and Measurement in Madura cattle at one day of age.

Parameter	n	$H^2 \pm SE$
Birth Weight	144	0.33 ± 0.26
Withers Height	144	0.35 ± 0.27
Body Length	144	0.64 ± 0.37
Chest Girth	144	0.49 ± 0.32

n = total of sample

The high category of heritability in Madura cattle at one day of age was on body length. The value of 0.64 ± 0.37 means that 64 % of the phenotypic variance on body length is caused by genetic factors. In contrast, 36% is caused by environmental factors factor.

Heritability values on withers height and chest girth were 0.35 ± 0.27 dan 0.49 ± 0.32. Adinata. (2013) states that heritability in the animal breeding field was vital because heritability can give information about how high a trait can be inherited by the parent to the offspring. Tonbesi et al. (2009) state that cattle's growing ability and production can be seen from body performance of a cattle-like body length, withers height, chest girth, chest width, and heat index.

Breeding Value (BV)

Breeding value estimation in this research using ten pure males Madura cattle shown in Table 4. The average body measurement and birth weight of every male showed in Table 3. Estimation result of breeding value from 10 males based on birth weight showed that 60% of male Madura cattle had a positive value (above group average) they were Montahai/1611001 (+1.18 kg), Ke Lesap/160725 (+1.02 kg), Benteng/934 (+0.78 kg), 671 (+0.53 kg), Buston/160724 (+0.44 kg), 684 (+0.04 kg). Meanwhile, the breeding value of withers height, body length, and chest girth in males showed that 40% (from 10 heads) of males had a positive value with the average of superior body performance above the average population. Males with positive value on birth weight were not necessarily had a positive value on body measurement, in Ke lesap male that reaches 2nd rank with positive value on birth weight (+1.02 kg), meanwhile on withers height (-0.45 cm) and body length (-3.25cm) had a negative value and got the 6th rank and 9th rank, respectively.

Males with positive value (above group average) were Montahai/ 1611001, Benteng/ 934 dan 671. Montahai/ 1611001 had the highest breeding value on body weight and withers height (+1.18 kg), bodyweight average of 17.82 ± 2.57 kg, and (+3.88 cm) with withers height average of 65.89 ± 4.58 cm. Said et al. (2020) state that the breeding value in Bali cattle in Lombok and Sumbawa was + 3.74 kg with a birth weight average of 20 kilograms and + 6.07 kg with an average of 15.23 kg. Meanwhile, the highest breeding value on body length was obtained by Buston/160724 (+7.89 cm) with an average value of 57.08 ± 6.97 cm, and on chest, girth got by male 671 (+4.05 cm) with average value 64.42 ± 4.63 cm.

In this research, the breeding value was obtained from the average body measurement and birth weight of the offspring; the purpose of a ranking method for breeding value was to maintain the males as a semen source. Males with positive and high breeding values can inherit their superior genetic potential to the offspring. No male evaluation process can cause negative breeding values, so cattle with low heritability are still males. American

Simmental Association and American Hereford Association reduce genomic predictors included in National Cattle Evaluations (Kachman et al., 2013).

The selection program and mating management can change the average birth weight and body measurement of every male offspring with positive breeding values and the population ranking sequence. Hardjosubroto. (1994) Breeding value had a significant meaning; if males' breeding value were known and then mated with random cattle, then average measurement of the offspring will show half of the male's superiority.

And they were resulting superior offspring above the population average where the cattle was lived.

Tabel 3. Average Performance and Standard Error (SE) of Birth Weight (BW), Withers Height (WH), Body Length (BL), and Chest Girth (CG) of Offspring in every male.

Males	n	Parameter			
		BW ± SE (kg)	WH ± SE (cm)	BL ± SE (cm)	CG ± SE (cm)
Montahai/1611001	19	17.82 ± 2.57	65.89 ± 4.58	50.97 ± 3.02	60.49 ± 4.60
Ke lesap/160725	5	18.5 ±2.26	62.18 ± 4.42	47.10 ±6.90	60.60 ± 6.23
Benteng/934	29	17.43 ± 2.29	64.58 ± 4.73	52.44 ± 4.32	61.36 ± 3.16
671	5	17.74 ± 2.08	64.50 ± 6.22	54.82 ± 6.12	64.42 ± 4.63
Buston/160724	10	17.35 ± 2.05	62.21 ± 6.97	57.08 ± 6.97	59.33 ± 5.56
684	17	16.92 ± 2.89	64.58 ± 3.39	48.28 ± 4.19	58.45 ± 3.19
Adikara/160726	17	16. 67± 2.89	62 ± 4.66	49.33 ± 4.01	56.42 ±4.65
685	14	16.32 ± 2.58	62.67 ± 5.03	49.23 ± 8.62	58.08 ± 4.75
386	22	15.85 ± 2.03	61.79 ± 3.48	49.55 ± 3.18	58.12 ± 5.00
10/387	6	14.15 ± 0.99	58.35 ± 5.54	49.63 ± 4.60	57.72 ± 3.59

n = total of sample

Table 4. Breeding Value (BV) estimation based on Birth Weight (BW), Withers Height (WH), Body Length (BL), and Chest Girth (CG) in Madura cattle at one day of age.

Males	n	BW (kg)	R	WH (cm)	R	BL (cm)	R	CG (cm)	R
Montahai/1611001	19	1.18	1	3.88	1	0.21	4	1.44	3
Ke lesap/160725	5	1.02	2	-0.45	6	-3.25	9	0.91	4
Benteng/934	29	0.78	3	2.49	2	2.71	3	2.99	2
671	5	0.53	4	1.05	4	3.89	2	4.05	1
Buston/160724	10	0.44	5	-0.65	8	7.89	1	-0.20	5
684	17	0.04	6	2.11	3	-3.93	10	-1.47	6
Adikara/160726	17	-0.26	7	-1.08	7	-2.33	7	-4.33	10
685	14	-0.57	8	-0.23	5	-2.35	8	-1.88	8
386	22	-1.37	9	-1.47	9	-2.07	6	-2.08	9
10/387	6	-1.90	10	-3.28	0	-1.29	5	-1.63	7

n = total of sample, R= Rank

Spearman Correlation Coefficient

Spearman correlation is used to correlate two variables with ordinal scale data (Usman and Akbar., 2020).

The result analysis value of Spearman correlation based on breeding value estimation in birth weight with chest girth and birth weight with withers height were 0.78 and 0.73 (Table 5). It showed a correlation between the breeding value of the birth weight with chest girth as much as 78% and birth weight with withers height was 73%. The result indicated that the bodyweight was highly correlated with chest girth and withers height performance.

Spearman correlation coefficient of birth weight with body length value 0.22 means a correlation of body weight with body length as much as 22% and categorized as low. (Boligon et al., 2016; Seftiana et al., 2019) Spearman correlation of body weight and body measurement was around 0.14 until 0.88 on Nelore cattle and 0.94 for birth weight of Bali cattle

Table 5. Spearman Coefficient Correlation in Birth Weight with Body Measurement in Madura cattle at one day of age.

Parameter	n	Spearman Correlation
Birth Weight with Withers Height	10	0.73
Birth Weight with Body Length	10	0.22
Body Weight with Chest Girth	10	0.78

n = total of sample

CONCLUSIONS

Heritability value in this research categorized as a medium until high, 60% from 10 head of male Madura cattle showed positive breeding value for body weight at one day of age, meanwhile for body measurement where 40% had positive breeding value. The highest breeding value of body weight and body measurement of Madura cattle at one day of age was sire Montahai/1661100. Strong Spearman correlation was performed between the rank of breeding value between birth weight with withers height and chest girth and the result. The genetic of pure Madura cattle in the breeding center area can be improved by selecting a program based on the breeding value of wither height and chest girth.

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REFERENCES

Adinata, Y. (2013). Sapi Peranakan Ongole Pada Unit Pengelolaan Bibit Sumber di Loka Penelitian Sapi Potong. *Prosiding Seminar Nasional Teknologi Peternakan Dan Veteriner*, 66–77.

Afroz, M., Hoque, M. A., & Bhuiyan, A. (2011). Estimation of heritability for growth traits of Red Chittagong cattle in a nucleus herd. *Bang. Vet*, *28*(1), 39–46. https://doi.org/10.3329/BVET.V28I1.8812

Aksakal, V., Bayram, B., Yanar, M., & Akbulut, O. (2012). Estimation of variance components and heritability of birth weight through different methods in Swedish Red and White cattle. *Journal of Animal and Plant Sciences*, *22*(1), 39–43.

Ashari, M., Suhardiani, R. R. A., & Andriati, R. (2019). Tampilan bobot badan dan ukuran linier tubuh domba ekor gemuk pada umur tertentu di Kabupaten Lombok Timur. *Jurnal Ilmu Dan Teknologi Peternakan Indonesia (JITPI), Indonesian Journal of Animal Science and Technology*, *1*(1), 20–24. https://doi.org/10.29303/jitpi.v1i1.6

Bene, S., Szűcs, M., Polgár, P., & Szabó, F. (2020). Ranking of beef cattle sires by their breeding value on progeny performance. *Journal of Central European Agriculture*, *21*(4), 697–706. https://doi.org/10.5513/JCEA01/21.4.2821

Beyleto, V. Y., Sumadi, S., & Hartatik, T. (2012). Estimasi parameter genetik sifat pertumbuhan kambing boerawa di Kabupaten Tanggamus Propinsi Lampung. *Buletin Peternakan*, *34*(3), 138–144. https://doi.org/10.21059/buletinpeternak.v34i3.82

Boligon, A. A., Vicente, I. S., Vaz, R. Z., Campos, G. S., Souza, F. R. P., Carvalheiro, R., & Albuquerque, L. G. (2016). Principal component analysis of breeding values for growth and reproductive traits and genetic association with adult size in beef cattle1. *Journal of Animal Science*, *94*(12), 5014–5022. https://doi.org/

10.2527/jas.2016-0737

Bureš, D., & Bartoň, L. (2012). Growth performance, carcass traits and meat quality of bulls and heifers slaughtered at different ages. *Czech Journal of Animal Science*, *57*(1), 34–43. https://doi.org/10.17221/5482-CJAS

H.M, N.-F. (2012). Estimation of genetic parameters for preweaning and postweaning growth traits in the Gudali beef cattle using multiple trait derivative free restricted maximum likelihood. *African Journal Of Biotechnology*, *11*(78), 14410–14416. https://doi.org/10.5897/AJB12.1038

Hardjosubroto, W. (1994). *Aplikasi Pemuliabiakan Ternak di Lapangan*. Gramedia Widiasarana.

Hoffmann, I. (2010). Climate change and the characterization, breeding and conservation of animal genetic resources. *Animal Genetics*, *41*, 32–46. https://doi.org/10.1111/j.1365-2052.2010.02043.x

Hossain, S. M. J., Bhuiyan, A. K. F. H., Kabir, M. A., Miraz, M. F. H., & Habib, M. (2018). Growth performance of red chittagong cattle based on phenotypic and genetic parameters. *International Journal of Animal Science*, *2*(1025).

Kachman, S. D., Spangler, M. L., Bennett, G. L., Hanford, K. J., Kuehn, L. A., Snelling, W. M., Thallman, R. M., Saatchi, M., Garrick, D. J., Schnabel, R. D., Taylor, J. F., & Pollak, E. J. (2013). Comparison of molecular breeding values based on within- and across-breed training in beef cattle. *Genetics Selection Evolution*, *45*(1), 30–45. https://doi.org/10.1186/1297-9686-45-30

Martojo, H. (2012). Indigenous Bali cattle is most suitable for sustainable small farming in Indonesia. *Reproduction in Domestic Animals*, *47*, 10–14. https://doi.org/10.1111/j.1439-0531.2 011.01958.x

Nijman, I. J., Otsen, M., Verkaar, E. L. C., de Ruijter, C., Hanekamp, E., Ochieng, J. W., Shamshad, S., Rege, J. E. O., Hanotte, O., Barwegen, M. W., Sulawati, T., & Lenstra, J. A. (2003). Hybridization of banteng (Bos javanicus) and zebu (Bos indicus) revealed by mitochondrial DNA, satellite DNA, AFLP and microsatellites. *Heredity*, *90*(1), 10–16. https://doi.org/10.1038/sj.hdy.6800174

Nurgiartiningsih, V. M. A. (2011). Peta potensi genetik sapi Madura murni di empat Kabupaten di Madura. *TERNAK TROPIKA Journal of Tropical Animal Production*, *12*(2), 25–34. https://doi.org/10.21776/UB.JTAPRO

Nurgiartiningsih, V. M. A. (2017). *Pengantar Parameter Genetik pada Ternak*. UB Press.

Nurgiartiningsih, V M A, Furqon, A., Rochadi, I., Rochman, A., Muslim, A., & Waqid, M. (2020). Evaluation of birth weight and body measurements of Madura Cattle based on year of birth and breeding system in Madura breeding centre, Indonesia. *IOP Conference Series: Earth and Environmental Science*, *478*(1), 012090. https://doi.org/10.1088/1755-1315/478/1/012090

Nurgiartiningsih, Veronica Margareta Ani, Budiarto, A., Kusmartono, K., & Suyadi, S. (2016). Evaluation of performance in female madura cattle in Madura Island, Indonesia. *Animal Production*, *18*(3), 125–130. https://doi.org/10.20884/1.anprod.2016.18.3.573

Ozkaya, S. (2013). The prediction of live weight from body measurements on female Holstein calves by digital image analysis. *The Journal of Agricultural Science*, *151*(4), 570–576. https://doi.org/10.1017/S002185961200086X

Papatungan, U., Lentji, R. N., & Hengky, J. K. (2015). Calf birth weight prediction accuracy using calf parturition, durability and metric body measurement in ongole crossbreeds heifers. *Int. J. Biol. Sci*, *2*(1), 10–14.

Park, S. J., Beak, S.-H., Jung, D. J. S., Kim, S. Y., Jeong, I. H., Piao, M. Y., Kang, H. J., Fassah, D. M., Na, S. W., Yoo, S. P., & Baik, M. (2018). Genetic, management, and nutritional factors affecting intramuscular fat deposition in beef cattle — A review. *Asian-Australasian Journal of Animal Sciences*, *31*(7), 1043–1061. https://doi.org/10.5713/ajas.18.0310

Putra, W. P. B., Sumadi, Hartatik, T., & Saumar, H. (2015). Progeny test program for Aceh cattle in the breeding center at indrapuri district, Indonesia. *J. Anim. Sci*, P1113–P1118.

Rakwadi, E., Nsoso, S. J., Gondwe, T. N., & Banda, J. W. (2016). 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), 2–11. http://researchhub.buan.ac.bw:80/handle/123456789/215

Regatieri, I. C., Boligon, A. A., Baldi, F., & Albuquerque, L. G. (2012). Genetic correlations between mature cow weight and productive and reproductive traits in Nellore cattle. *Genetics and Molecular Research*, *11*(3), 2979–2986. https://doi.org/10.4238/2012.May.10.4

Said, S., Putra, W. P. B., Muzawar, M., & Kantong, S. A. (2020). Selection of Bali cattle based on birth weight and calving interval records at West Nusa Tenggara Province of Indonesia. *Journal of the Indonesian Tropical Animal Agriculture*, *45*(1), 15–27. https://doi.org/10.14710/jitaa.45.1.15-27

Supriyantono, A., Hakim, L., Suyadi, S., & Ismudiono, I. (2012). Genetic improvement of weaning weight, yearling weight, body weight gain and body dimension of Bali cattle. *Journal of the Indonesian Tropical Animal Agriculture*, *37*(1), 10–14. https://doi.org/10.14710/jitaa.37.1.10-14

Sutarno, S., & Setyawan, A. D. (2015). Review: Genetic diversity of local and exotic cattle and their crossbreeding impact on the quality of Indonesian cattle. *Biodiversitas Journal of Biological Diversity*, *16*(2), 327–354. https://doi.org/10.13057/biodiv/d160230

Tonbesi, T. T., Ngadiyono, N., & Sumadi, S. (2012). Estimasi potensi dan kinerja sapi Bali di Kabupaten Timor Tengah Utara, Propinsi Nusa Tenggara Timur. *Buletin Peternakan*, *33*(1), 1–7. https://doi.org/10.21059/buletinpeternak.v33i1.132

Tribudi, Y. A., Prihandini, P. W., Rahaddiansyah, M. I., & Anitasari, S. (2021). Seleksi calon pejantan dan induk sapi Madura berdasarkan nilai pemuliaan berat lahir dan sapih. *Jurnal Sain Peternakan Indonesia*, *16*(1), 1–7. https://doi.org/10.31186/jspi.id.16.1.1-7

Trihendradi, C. (2009). *Step by Step SPSS 16 Analisis Data Statistik*. Andi Ofset.

Usman, H., & Akbar, R. P. S. (2020). *Pengantar Statistika*. Bumi Aksara.

Vostrý, L., Milerski, M., Krupa, E., Veselá, Z., & Vostrá-Vydrová, H. (2015). Genetic relationships among calving ease, birth weight and perinatal calf survival in Charoláis cattle. *Animal Science Papers and Reports*, *33*(3), 233–242.

Widyas, N., Prastowo, S., Widi, T. S. M., & Baliarti, E. (2018). Predicting Madura cattle growth curve using non-linear model. *IOP Conference Series: Earth and Environmental Science*, *142*, 012006. https://doi.org/10.1088/1755-1315/142/1/012006