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Selection of Simmental Bulls (*Bos taurus*) Based on MPPA for Sperm Quality Traits

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Abstract. Simmental cattle (*Bos indicus*) are the famous beef cattle in Indonesia. Presently, the straws of Simmental bull were produced in many artificial insemination centers (AIC) of Indonesia. This study was aimed to evaluate the Simmental bulls at AIC Tuah Sakato of West Sumatra - Indonesia based on most probable producing ability (MPPA) value. Total 20 Simmental bulls with 2,793 data records of sperm quality traits (sperm volume, sperm motility, sperm concentration) were used for the investigation. Research showed that the average of sperm volume (SV), motility rate (MR) and sperm concentration were 6.36±0.82 mL; 55.96±12.22% and 1365.54±153.36 (×10^6), respectively. Therefore, the repeatability (r) value of SV and MR traits were classified in low category (<0.10). While, the r value in SC trait was showed in moderate category (0.10-0.30). In additon, the highest MPPA value of SV, MR and SC traits were +1.00 (Bull ID: 61757), +9.23 (Bull ID: 62168) and +365.90 (Bull ID: 61654), respectively. It can be concluded that the high variation of sperm quality traits in animals under study can be caused by many environmental factors such as: air temperature, nutrition, season and health status. Hence, annual management sysytem evaluation is important to optimize the productivity of bulls.

Keywords: MPPA (Most Probable Producing Ability), Sperm quality traits, Sperm concentration, Sperm motility, Simmental bulls

1. Introduction

Simmental cattle (*Bos taurus*) are the famous beef cattle with high economic value. Currently, the Simmental bulls have been kept in many Artificial Insemination Centers (AIC) of Indonesia for frozen sperm production. The body weight and carcass weight of SimPO cattle (Simmental × Ongole grade) were 458.68±63.12 kg and 235.10±41.09 kg, respectively [1]. Despite this, the SimBal cattle (Simmental × Bali) had the body weight of 365.12±38.37 kg [2]. In addition, the Simmental cattle had the heritability (h^2) value of 0.84±0.33 for birth weight (BW) trait; 0.81±0.32 for weaning weight (WW) trait and 0.70±0.30 for pre-weaning daily gain (ADG) trait [3]. In addition, a Simmental bull (W. Drovin) able to attain the Estimated Breeding Value (EBV) of +0.10 (BW), +60.93 (WW) and +0.28 (ADG) [3].

Despite of EBV, the Simmental bulls can be selected based on their sperm quality traits by estimating the Most Probable Producing Ability (MPPA). The MPPA is used to select animals based on their potency. In general, the MPPA value can be estimated based on two data records (interclass correlation) and more than two records (ANOVA) [4, 5]. In the WW traits of Simmental cattle, the MPPA value was recorded about 140.00 kg [6]. While, the MPPA value in sperm quality traits of Simmental bulls is not reported. As kept for straw production, assessing MPPA to select Simmental bulls is important for obtaining the bulls with consistent records. Hence, the repeatability (r) value is used in MPPA estimation. Repeatability is the one of genetic parameters that used for conventional selection. Repeatability can indicate the phenotype correlation between the current and future of animal's performance [7]. Animals with high r value indicating the consistency in every production period. The r value had three categories of low (<0.30), moderate (0.31 - 0.50) and high (>0.50) [8].

This study was aimed to select Simmental bulls based on MPPA value of sperm quality traits (sperm volume, sperm motility and sperm concentration). The results of this study are important to evaluate the management system that influencing the consistency of sperm quality records in Simmental bulls.

2. Research Methods

2.1 Animals

Total of 2,793 records data of fresh semen quality traits from year 2022 to 2025 were used in this study. The data was collected from 20 certified Simmental bulls from Artificial Insemination Center (AIC) Tuah Sakato, West Sumatra Province, Indonesia. This area located at longitude 100°35'-100°45' E and latitude 00°10'- 00°17' S. The average of rainfall in this place about 1,576.80 mm/year with air temperature about 25.0- 27.0°C and relative humidity about 45-50 %. All bulls were kept individually and receive similar daily ration and care management. The ration composition for each bull consisted of Elephant grass (10.21% DM; 51.33% TDN; 10% CP; 1% CF), concentrate (90.49% DM; 72.96% TDN; 14.44 CP; 6.17% CF) and water given with *ad libitum.*

2.2 Collection Process and Semen Evaluation

Semen of Simmental bulls were collected every morning (08.00 am) twice a week using artificial vagina. Each semen collection consisted of two ejaculations. The semen evaluation consisted of semen volume (SV), motility rate (MR) and sperm concentration (SC). Data of SC was evaluated using photometer (SDM 6 Minitub, Germany). Thus, data of VS and MR were evaluated using objective microscope. The semen collection procedure was performed according to the standard operational procedure (SOP) in AIC and Indonesian national standard (INS).

2.3 Data analysis

The descriptive statistics of each sperm quality trait were calculated using SPSS 16.0 package. Therefore, the repeatability (r) was calculated with ANOVA method following the mathematical formulas as follow [9]:

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

$$SE(r) = \sqrt{\frac{2(1-r)^2[1+(k-1)r]}{k(k-1)(n-1)}}$$

$$k = \frac{1}{S-1}\left(\Sigma n \frac{\Sigma n^2}{n}\right)$$

where, r is the repeatability; σ_s^2 is the variance among bulls; σ_w^2 is the variance of data records; SE(r) is the standard error of heritability; k is the constanta and n is the number of data records.

Therefore, the Most Probable Producing Ability (MPPA) was estimated using a mathematical formula as follows [8]:

$$MPPA = \frac{nr}{1+(n-1)r}(\bar{p} - \bar{\bar{p}})$$

where, MPPA is the Most Probable Producing Ability; n is the number of data records, $\bar{p}$ is the average of individual trait and $\bar{\bar{p}}$ is the average of population trait

3 Results and Discussion

The descriptive statistics of sperm quality traits of Simmental bulls under study was presented in Table 1. A previous study reported that the Austrian Simmental bulls had the SV (6.29±2.50 mL) and MR (67.10±4.90 %) that close to the present study [10]. Despite this, the sperm quality traits (SV, MR, SC) has been reported in many cattle breeds such as Sahiwal (3.79±0.02 mL; 55.47±0.001 %; 766.69±5.50 ×10^6/mL) [11], Karan Fries (4.45±0.10 mL; 46.73±0.03 %; 839.25±27.38 ×10^6/mL) [12], Madura (4.08±1.66 mL; 61.60±16.5 %; 1,059.00±421.50 ×10^6/mL) [13], Ongole grade (5.90±1.92 mL; 58.10±14.78 %; 1,356.30±480.51 ×10^6/mL) [14], Friesian Holstein (7.54±2.19 mL; 66.44±0.10 %; 1,220.27±505.80 ×10^6/mL) [15] and Bali (3.74±1.68 mL; 64.89±10.08 %; 1091.20±496.99 ×10^6/mL) [16]. The sperm quality traits of cattle could be caused by different of breeds (genetic), climate and management system.

Table 1. Descriptive statistics in the sperm quality traits of Simmental bulls (*Bos taurus*) at AIC Tuah Sakato, West Sumatra

Traits	Mean	SD	CV (%)	Minimum	Maximum
Sperm volume (mL)	6.36	0.82	12.93	4.30	7.92
Motility rate (%)	55.96	12.22	21.83	27.95	36.99
Sperm concentration (×10^6/mL)	1365.54	163.36	11.96	1089.66	1815.68

SD: standard deviation; CV: coefficient of variation

The r values in the animals under study were under in low category (Table 2). A previous study reported the moderate / high r value (SV & MR) in many cattle breeds such as Friesian (0.34 & 0.20), Local × Friesian (0.59 & 0.39) and Sahiwal × Friesian (0.39 & 0.50) [17]. In addition, low to high r value of sperm quality traits (SV, MR, SC) were showed in many Indonesian cattle breeds such as: Madura (0.38; 0.58; 0.45) [13], Ongole grade (0.48; 0.01; 0.42) [14], Friesian Holstein (0.54; 0.30; 0.43) [15] and Bali (0.23; 0.10; 0.53) [16]. Despite this, many previous studies reported low to moderate r value in sperm quality traits (SV, MR, SC) in Friesian Holstein (0.41; 0.16; 0.18) and Holstein cross (0.21; 0.45; 0.28) bulls [18, 19]. The r value can be influenced by health status, management system and annual temperature and climate. While, the number of records and type statistical metods can conduct the different repeatability calculation result.

Table 2. The repeatability value of sperm qulity traits in Simmental bulls (*Bos taurus*) at AIC Tuah Sakato, West Sumatra

Traits	Repeatablity
Sperm volume	0.016±0.004
Motility rate	0.082±0.008
Sperm concentration	0.101±0.009

The highest of MPPA value in observed traits were about +1.00 (SV), +9.23 (MR) and +365.90 (SC) as shown in Table 3. According to the MPPA rank, Bulls ID: 61757, 62168 and 61654 had the highest MPPA value for SV, MR and SC traits, respectively (Fig. 1). Moreover, Bull ID: 62170 is observed as five the best bulls for each trait. It can be suggested that a bull with highest MPPA value indicating this bull had the highest traits in their population. While, a positive value explained that the individual traits are higher than average traits of population. Consequently, bulls with negative or lowest MPPA value must be removed from population because of low genetic potency. Despite of Simmental cattle, the MPPA was applied to select Aceh [20], Brahman [21], Ongole grade [22], Madura [23] and Friesian Holstein [24] cows in Indonesia.

Table 3. Five the best Simmental bulls (*Bos taurus*) based on MPPA of sperm quality traits

Traits	Rank	MPPA	N	Bull ID
Sperm volume	1	+1.00	190	61757
	2	+0.70	125	62170
	3	+0.28	102	61756
	4	+0.27	177	61961
	5	+0.23	186	61754
Motility rate	1	+9.23	132	62168
	2	+6.57	120	62169
	3	+6.29	125	62170
	4	+4.32	59	61654
	5	+1.08	177	61961
Sperm concentration	1	+365.90	59	61654
	2	+215.73	113	61344
	3	+64.84	125	62170
	4	+62.76	132	62168
	5	+28.23	177	61961

MPPA: most producing probable ability; N: number of data records

Bull ID: 61757 | Bull ID: 62168 | Bull ID: 61654

Figure 1. The best Simmental bulls based on MPPA of sperm volume (Bull ID: 61757), motility rate (Bull ID: 62168) and sperm concentration (Bull ID: 61654)

4 Conclusion

The r value Simmentalbulls under study was low and indicating the highly temporal environment effect. However, the best five bulls were selected based on MPPA of sperm quality traits with positive value. In the future, improving the management system is important to reduce the external factors that affecting the reproductive performance of bulls.

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