Estimation of most probable producing ability of Bali cattle semen quality

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Abstract. This study aims to estimate the Most Probable Producing Ability (MPPA) values of semen quality in five Bali cattle bull that collected from January to October 2016 at Singosari AI Center. The semen quality parameter consists of semen volume (ml), motility (%), concentration (x10^6), and total sperm (x10^9/ml) observed in rainy and dry season. Data were analyzed using intraclass correlation to estimate the repeatability and MPPA values. The average of semen quality in rainy and dry seasons, respectively, in volume were 3.91-6.24 ml and 4.38-6.84 ml, motility was 46.31-70.00% and 48.26-70.45%, semen concentrations were 844.78-1059.02 × 10^6/ml and 1033.15-1260.16 × 10^6/ml, and total sperm were 3280.58-5964.50 × 10^6 and 4493.31-7206.96×10^6. In this study, dry season shows better semen quality parameter as well as the repeatability value, therefore the estimation of MPPA in dry season is more accurate compared to rainy season.

1. Introduction
Bali cattle is a native local cattle from Indonesia, which has advantages such as high adaptability to tropical environment, high fertility, and high carcass percentage [1]. To improve the Bali cattle genetic quality, artificial insemination (AI) is commonly practiced using best selected bulls. One of factor affecting AI success is semen quality and its production capability during semen collection. Information of semen quality from each individual bull could be used to expected result of semen dosage for AI.

Singosari AI Center is an Indonesian government agency which has function to produce frozen semen from Bali cattle and to disseminated for AI program. In that center, semen from selected Bali cattle bulls were collected, evaluated, processed, and stored for further use in improving Bali cattle population and genetic quality. The use of Bali cattle bulls for semen source in Singosari AI Center, can be last for 5-7 years on average. The continuous function as semen producer resulting a repetitive data that can be referred as repetition rates or repeatability.

Repeatability is one of genetic parameters that appear repeatedly in the life of an animal [2]. Repeatability can show how similar a trait produced in a period compared to subsequent periods. The repetitive semen production and its quality can be used for further evaluation of male reproductive ability of Bali cattle.

Repeatability can be used as a parameter in estimating the productivity of trait(s) and to see the trait consistency in each period. Estimating the productivity of a trait can be done by determining the value of Most Probable Producing Ability (MPPA). The value of MPPA is the maximum estimation of
production ability of cattle which is calculated based on the existing performance records and used for selection of cattle that has high productivity [3]. For that, in the current study MPPA will be employed to estimate the consistency and productivity of Bali cattle semen quality.

2. Materials and methods

2.1. Data collection
This study uses data of semen production collected from five bulls of Bali cattle at Singosari AI Center from January to October 2016. Data the divided into rainy (January-April) and dry (June-September) season. Seasons were determined according to the rainfall data retrieved from local weather stations [4]. Moreover, semen quality parameters were observed in volume (ml), motility (%), sperm concentration (x10^6/ml), and total sperm (x10^6).

2.2. Data analysis
The data analysis to obtain repeatability was performed according to the earlier study [3] which using one-way variance method with an unequal number of measurements per individual. The model is as follows:

\[ Y_{km} = \mu + \alpha_k + \varepsilon_{km} \]

With:
- \( Y_{km} \): k-level individual semen production value from m-measurement record
- \( \mu \): average semen production of the population
- \( \alpha_k \): individual influence i-th
- \( \varepsilon_{km} \): deviation due to uncontrolled environmental influence on the i-th individual from the k-th measurement record

Next, the MPPA is estimated using the following equation [5]:

\[ \text{MPPA} = \frac{nr}{1+(n-1)r} (\bar{P}_i - \bar{P}) \]

With:
- \( n \): number of cattle counted
- \( r \): repeatability value
- \( \bar{P}_i \): the average of n previous records on cattle i
- \( \bar{P} \): the average of all cattle population

3. Results and discussion

3.1. Semen quality parameter of Bali cattle bull during observation time
Semen was collected from five bulls of Bali cattle (ID: 11288, 11289, 11291, 11292, and 11293) in rainy and dry season. In this study, semen collection was performed using artificial vagina at interval two times per week. As the result, semen quality parameter during observation time is summarized in Table 1.

| Table 1. The range of semen quality value of five Bali cattle bulls in different season |
|---------------------------------------------|------------------|------------------|
| Semen quality parameter                     | Rainy season     | Dry season       |
| Volume (ml)                                 | 3.91 - 6.24      | 4.38 - 6.84      |
| Motility (%)                                | 46.31 - 70.00    | 48.26 - 70.45    |
| Sperm concentration (x10^6/ml)              | 844.78 - 1059.02 | 1033.15 - 1260.16 |
| Total sperm (x10^6)                         | 3280.58 - 5964.50 | 4493.31 - 7206.96 |
Seminal volume parameter is required to determine the fresh semen quantity after collection [6]. In this study, we found that the monthly average of seminal volume in each individual bull in rainy and dry seasons is vary (Figure 1). One of factor affected seminal volume difference between time of collection and also between bulls is season [7]. Different season may modulate the production of Follicle Stimulating Hormone (FSH), which function for spermatogenesis [8]. Moreover, seminal volume also affected by age [9] and correlated with testicular size [10].

**Figure 1.** Graph of the average monthly Bali cattle seminal volume in the rainy and dry seasons

In the percentage of sperm motility, we found the variation between bull and season (Figure 2). The motility is considered as an important sperm quality, due to it has positive correlation to the ability of sperm to fertilize ovum [6]. In the AI center, minimum sperm motility is 60% to be eligible for frozen semen production [11]. According to previous study [7], sperm motility parameter is influenced by season. Dry season shows better motility compared to rainy.

**Figure 2.** Graph of the average Bali cattle seminal motility every month in the rainy and dry seasons

Sperm concentration is the number of sperm in one ml of ejaculate, while total sperm is calculated by multiple sperm concentration with volume of fresh semen per ejaculate. Those parameters are important for calculating the dosage of straw of frozen sperm. The higher sperm concentration and seminal volume will resulted more total sperm [11]. Both qualities are important parameter to predict bull productivity in sperm production. According to the result, dry season yielded more sperm per ml of ejaculate as well as in total sperm (Table 1) when compared to ejaculate resulted in rainy season. In this parameter we also see the fluctuation and individual variation among bulls and season (Figure 3 and Figure 4). The difference in average of sperm concentration and seminal volume in both seasons affect the average of total sperm produced. In here, season is the factor that affect total sperm yielded. The different of FSH production during dry and rainy season suggested to be factor affected spermatogenesis in the testes [12].
Figure 3. Graph of average concentration of Bali cattle sperm every month in the rainy and dry seasons

Figure 4. Graph of the average monthly Bali cattle total sperm in the rainy and dry seasons

3.2. Repeatability

Repeatability can be interpreted as the correlation between current performance and subsequent performance. Repeatability of a trait is useful in predicting future productivity of cattle that already has one or more production records [2]. The results of repeatability calculation of each individual in rainy and dry season are shown in Table 2.

| Bull ID | Volume Rainy | Motility Rainy | Concentration Rainy | Total Sperm Rainy | Volume Dry | Motility Dry | Concentration Dry | Total Sperm Dry |
|---------|--------------|----------------|---------------------|------------------|------------|--------------|------------------|----------------|
| 11288   | 0.21         | NA             | 0.24                | 0.07             | 0.41       | 0.02         | 0.24             | 0.67           |
| 11289   | 0.71         | 0.72           | 0                   | 0.32             | 0          | 0.33         | 0.75             | 0.03           |
| 11291   | 0.97         | 0              | 0.14                | 0.79             | 0          | 0            | 0.79             | 0              |
| 11292   | 0.28         | 0.37           | 0.33                | 0.42             | 0          | 0.33         | 0.75             | 0              |
| 11293   | 0            | 0.15           | 0                   | 0.16             | 0.30       | 0            | 0                | 0              |

Repeatability can be classified into three categories, namely low (< 0.1); medium (0.1-0.3) and high (>0.3). The magnitude of repeatability from population to population or over time is not fixed and can be vary [3]. As seen in Table 2, the repeatability value of each individual parameter per bulls are varies in both seasons. In all sperm quality parameter observed we found repeatability value which categorized low, medium, and high. For example, in volume parameter we found repeatability which < 0.1, and > 0.3. This means that there is variation in sperm production in each bull between individual and season.

Low repeatability means the semen production is not consistent. Meanwhile high repeatability can be assumed that the trait will repeat in the next period. Low repeatability can be explained due to the influence of several factors namely time, environment, analytical method, and number of animals observed [4]. Especially environmental factor, different environment was expressed in different of season.
3.3. MPPA
MPPA is a maximum estimate value of the production ability of an animal based on the existing performance records. MPPA is an estimate that approaches the real production capability of an animal expressed as a deviation against the average group. In MPPA estimation, repeatability is used for calculation [2]. The MPPA in the current study, shows the consistency of animal performance in semen quality in different time of production. The calculation MPPA for each bull different season can be seen in Table 3.

Table 3. MPPA of Bali cattle semen quality in the rainy and dry season

| Bull ID | Motility | Concentration | Volume | Total Sperm |
|---------|----------|---------------|--------|-------------|
|         | Rainy    | Dry           | Rainy  | Dry         | Rainy | Dry |
| 11288   | NA       | 65.86         | 864.02            | 1115.62       | 4.04  | 4.44 |
| 11289   | 46.60    | 64.63         | 984.90           | 1143.60       | 4.45  | 5.19 |
| 11291   | 61.82    | 64.63         | 1041.61          | 1115.62       | 3.91  | 5.19 |
| 11292   | 61.82    | 68.15         | 1011.77          | 1074.19       | 4.51  | 5.19 |
| 11293   | 60.58    | 64.63         | 984.90           | 1115.62       | 4.61  | 6.67 |

The results of MPPA calculation compared to the data in the following month. The predicted results of MPPA values in rainy season are compared with the production data in May, while in the dry season are compared with production data in October. Comparisons were made to prove the prediction accuracy of the resulting MPPA values. High repeatability value means that the production is more consistent, if the production is consistent then the MPPA value will be more accurate or close to the real value in the next period. But if the repeatability value is low, then the production is inconsistent and the resulting MPPA value is less accurate.

For example, the predicted MPPA for semen volume of bull with ID 11289 and 11291 in rainy season were close to the next production value in May because of the high repeatability (Table 2). In dry season, semen volume of bull with ID 11288 based on the MPPA also close to next production value in October (4.05 ml). Both examples are the semen quality parameters which have high repeatability. The same pattern also applied to motility, sperm concentration, and total sperm which have high repeatability as well. High repeatability in sperm quality parameter gives accurate prediction of the next sperm production capabilities in each individual bulls.

4. Conclusion
The season affects semen quality in all parameters namely motility, concentration, volume, and total sperm. Semen quality in dry season shows better results than in rainy season. This study proves that high repeatability of sperm parameter shows the consistency of semen quality which exist in each period. High repeatability yielded more accurate estimation of MPPA values then can be considered as selection criteria.

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