Comparative evaluation of heritability value and non genetic factor affecting reproduction traits in Ongole cross cattle

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Abstract. Evaluation of genetic factors such as heritability value and non-genetic factors of reproductive traits has a vital role in improving breeding and management practices of beef cattle. The aim of the present study was to evaluate heritability value and non-genetic factors affecting reproductive traits in Ongole grade cattle. Five hundred and fifty-three (553) records of reproductive traits including age at first calving (AFC), calving interval (CI), days open (DO) of cows distributed over a period of 8 years (2012 to 2019) were used to predict genetic and non-genetic parameters. Parity, sex, mating system, season, and year of birth calf were included in the model to estimate their effect on reproductive traits. Heritability estimation was calculated using Mixed Model analysis by SAS 9.4. The General Linear Model (GLM) procedure of SAS program, version 9.4 was used to estimate non-genetic factors. Overall mean values for AFC, CI and DO were 39.62±0.39 months, 393.81±2.85 days, 84.29±0.34, respectively. The results revealed that AFC, CI and DO were significantly (P<0.01) affected by mating system but sex, parity, year of birth had no significant (P>0.05) influence. Concerning AFC, season affected AFC of Ongole grade. Prediction of heritability AFC, CI and DO were 0.28±0.026; 0.46±0.007 and 0.21±0.040, respectively. We might conclude that the improvement of reproductive traits in Ongole grade cattle was possible by improving genetic merit by selection criteria using genetic parameters and utilization of controlled breeding techniques.

1. Introduction

Ongole Cross cattle is a local cattle with a huge contribution to the production of beef in Indonesia. Ongole Cross cattle is a local cattle resulted from upgrading between Javanese cattle and Sumba Ongole (SO) that was introduced by Dutch government namely “Ongolization program” from 1915 to 1929. Comparing to other local cattle such as Madura cattle, Ongole Cross cattle have high diversity [1], able to survive in the condition of the tropical region and high adaptability [2] with less productivity compared to the Taurus breed cattle. Since the introduction of Artificial Insemination (AI) in 1970, mostly the farmers have been crossed Ongole Cross cows with Bos taurus breed [1]. As a result, breeders have recently preferred to produce crossbreds between Ongole Cross cattle and exotic breeds, such as Limousin, Brahman and Simmental to improve beef production to gain heterosis effect or hybrid vigor. These hybrids are more favorite for breeders and farmers as they have higher daily weight regardless of higher production costs. The uncontrolled crossbreeding between Ongole Cross cattle and exotic has undermined the importance of Ongole Cross cattle as animal genetic resources of Indonesia. Evaluation
genetic improvements of productive and reproductive traits of local cattle should be considered since lack of information on recording and identification in small farmer holder communities. The improvement of reproduction traits of Ongole Cross cattle through selection programs should consider the genetic parameters such as heritability value and non genetic factors that influence the reproduction of Ongole Cross cattle.

Several studies reported genetic and non-genetic effects in native cattle of Bali cattle for production traits including birth, weaning, and yearling weight [3-5] and reproduction trait, including AFC, CI, pregnancy rate, mortality and gestation length [6,7]. Gunawan et al. [3] stated that year of birth and season significantly affected all growth traits. Meanwhile, sex of calf had no significant effect on birth and weaning weight but had significantly affected yearling weight in Bali cattle. Regarding the genetic effects, predicted heritability of birth, weaning, and yearling weight of Bali cattle was 0.09±0.07, 0.33±0.09, and 0.43±0.10 [5]. Previous research on non-genetic effects of production traits in Ongole Cross cattle were reported by Hartati et al [1]. In Ongole Cross cattle, sex of calves and year of births had significant influence for all production traits, while the type of birth only revealed significantly affected on birth weight [1]. Furthermore, Hartati et al. [1] reported heritability estimation of birth, weaning, and yearling of Ongole Cross cattle were 0.28±0.12, 0.47±0.15 and 0.63±0.17, respectively. However, information of the genetic effect on reproductive performance in Ongole Cross cattle is very rare. For better understanding of genetic and non genetic effect of reproduction traits including age first calving (AFC), calving interval (CI) and days open (DO) in Ongole Cross cattle are warranted. Then, the aim of the present research was to evaluate genetic and non genetic factors affecting reproduction traits of Ongole Cross cattle.

2. Material and methods

2.1. Phenotype data of reproductive traits

The present research used the data recorded from Small Farmer Holder Community SPR Mega Jaya of Bojonegoro in East Java, Indonesia, from 2012 to 2019. Reproductive data from 556 heads of Ongole Cross calves were collected from 197 head dams and 359 heads sires. Data of individuals that were available include numbers of the calf, dam, and sire, date of birth, type of mating, sex, parity, years of birth, season, age at first calving (AFC), calving interval (CI) and days open (DO). Management of reproduction was mainly performed through artificial insemination (AI) using either frozen semen or natural breeding using purebred bulls. The data on reproductive traits, including AFC, CI and DO were presented in table 1.

Table 1. Reproductive performance of Ongole cross cattle.

| Traits | No. of records | Mean | Standard error | Coeff. of variation | Min | Max |
|--------|----------------|------|----------------|---------------------|-----|-----|
| AFC<sup>a</sup> | 561 | 39.62 | 0.39 | 23.38 | 24.00 | 72.00 |
| CI<sup>b</sup> | 538 | 393.81 | 2.85 | 16.81 | 365.00 | 790.00 |
| DO<sup>c</sup> | 537 | 84.29 | 0.34 | 9.61 | 55.00 | 120.00 |

<sup>a</sup>AFC: age first calving, <sup>b</sup>CI: calving interval, <sup>c</sup>DO: days open

2.2. Heritability estimation

Mixed models were used to estimate the heritability value of age at first calving (AFC), calving interval (CI), and days opens (DO). In this model, dam and sire were included as a random effect and account for the genetic effect.

The total variance and covariance components were sorted into additive and non-additive (environmental and residual genetic) components [8].

\[ Y_{ijk} = \mu + S_i + D_{ij} + E_{ijk} \]

\[ \mu = \text{Mean value} \]
S_i  = Effect of the i_th sire
D_{ij} = Effect of the j_th dam within the i_th sire
E_{ijk} = Uncontrolled environmental deviations

Heritability was estimated from dam and sire variance components, according to Becker [9] as below:

\[ h^2_d = 4\delta_d/ (\delta^2_s + \delta^2_d + \delta^2_w) \]

\( h^2_d \) = Heritability from dam component
\( \delta^2_s \) = Sire variance component
\( \delta^2_d \) = Dam variance component
\( \delta^2_w \) = Within progeny variance component

To estimate standard errors for heritability were analyzed according to [9]:

\[ SE (h^2_s+d) = \frac{4}{K^3S} \left[ \frac{MS^2_s}{S-1+2} + \frac{MS^2_d}{d-s+2} \right] \]

\[ K^3 = \frac{1}{S-1} \left[ \frac{N - \Sigma n^2 - 1}{n1} \right] \]

\( MS^2_d \) = Mean square dam
\( MS^2_s \) = Mean square sire
\( d^2_t \) = Total variance
\( d \) = Number of dam
\( s \) = Number of sire
\( K^3 \) = Number of progeny per sire

2.3. Non genetic effect

To determine the effect of non genetic factors, data reproductive traits including AFC, CI and DO were evaluated using analysis of General Linear Model (GLM) using SAS [10] with the mathematical models as follow:

\[ Y = \mu + p_i + q_i + r_i + s_i + t_i + e \]

\( Y \) = Age first calving (AFC), calving interval (CI) and days open (DO)
\( \mu \) = Overall mean
\( p_i \) = The effect of mating system (AI, naturally)
\( q_i \) = The effect of sex (male, female)
\( r_i \) = The effect of parity (1, 2, 3, 4, 5, 6, 7, 8)
\( s_i \) = The effect of year birth calf (2012-2019)
\( t_i \) = The effect of season (dry, rainy)
\( e \) = Random effect

3. Results and discussion

3.1. Reproductive traits of Ongole Cross cattle

Reproductive performance of non genetic effect and heritability value of age first calving (AFC), calving interval (CI) and Days open (DO) in Peranakan Ongole (PO) cattle are shown in table 2 and 3.
### Table 2. Non genetic analysis of reproductive traits of Ongole Cross cattle.

| Non genetic | Reproduction Traits | AFC(n)^a | CI (n)^b | DO(n)^c |
|-------------|---------------------|----------|---------|---------|
| Type of mating |                     |          |         |         |
| AI          |                     | 39.56±0.39^A (527) | 392.72±2.84^A (506) | 84.49±0.35^A (523) |
| Natural     |                     | 40.68±1.85^B (34)  | 411.10±1.70^A (32)  | 81.12±1.28^B (34)  |
| Sex         |                     |          |         |         |
| Male        |                     | 39.63±0.48(353)    | 391.98±3.12 (342)   | 84.20±0.44 (350)   |
| Female      |                     | 39.58±0.67 (523)   | 396.76±5.81 (190)   | 84.45±0.54 (201)   |
| Parity      |                     |          |         |         |
| 1           |                     | 38.66±0.72 (157)   | 398.56±6.68 (134)   | 85.08±0.72 (153)   |
| 2           |                     | 39.48±0.79 (131)   | 400.66±6.91 (131)   | 83.63±7.78 (131)   |
| 3           |                     | 40.65±0.95 (102)   | 392.17±6.08 (102)   | 83.56±0.75 (102)   |
| 4           |                     | 40.14±0.11 (78)    | 390.32±6.72 (78)    | 83.84±0.88 (78)    |
| 5           |                     | 40.48±1.42 (46)    | 381.70±6.78 (46)    | 84.57±1.14 (46)    |
| 6           |                     | 39.52±1.72 (25)    | 384.32±6.03 (25)    | 86.08±1.67 (25)    |
| 7           |                     | 38.48±1.73(21)     | 380.95±6.12 (21)    | 85.14±1.73 (21)    |
| Year of birth |                   |          |         |         |
| 2012        |                     | 36.07±1.75(14)     | 388.57±9.23 (14)    | 85.86±3.08 (14)    |
| 2013        |                     | 36.00±1.40 (30)    | 408.90±16.20 (30)   | 84.57±1.86(30)     |
| 2014        |                     | 38.60±1.47 (43)    | 385.30±4.38 (43)    | 84.42±1.20 (43)    |
| 2015        |                     | 40.14±0.11 (70)    | 396.57±8.69 (69)    | 83.74±0.99 (70)    |
| 2016        |                     | 40.07±0.99 (85)    | 385.19±6.78 (84)    | 84.55±0.82 (85)    |
| 2017        |                     | 40.14±0.99 (104)   | 398.15±7.58 (102)   | 86.08±1.67 (25)    |
| 2018        |                     | 40.11±0.87 (115)   | 394.44±7.14 (105)   | 83.86±0.80 (111)   |
| 2019        |                     | 39.99±1.00(86)     | 394.44±7.14 (77)    | 84.00±1.00 (86)    |
| Season      |                     |          |         |         |
| Dry         |                     | 38.67±0.50^A (344) | 397.44±3.94 (336)   | 84.48±0.45(343)    |
| Rainy       |                     | 40.91±0.61^B (212) | 387.81±3.86 (200)   | 84.00±1.00 (212)   |

Means in the same column with different superscript differ significantly (P<0.05);

^aAFC; Age First Calving, ^bCI: Calving Interval, ^cDO: Days Open

### Table 3. Heritability of reproductive traits of Ongole Cross cattle.

| Traits  | h^2a | VA^b | VE^c | VP^d |
|---------|------|------|------|------|
| AFC     | 0.28±0.026 | 50.298 | 127.891 | 178.189 |
| CI      | 0.46±0.007 | 5.439  | 6.356  | 11.795  |
| DO      | 0.21±0.040 | 19.476 | 73.27  | 92.746  |

h^2= heritability, VA= variance of additive, VE= variance of environment, VP= variance of phenotypic

3.2. Heritability estimation and non genetic effect

3.2.1. Age First Calving (AFC). Age of first calving (AFC) was significantly affected (P<0.05) by type of mating and season in Ongole Cross cattle, whereas, sex, year of birth calf and party revealed no influence effect (table 2). Calves born during rainfall were younger AFC compared to those born during dry periods. This fluctuation is caused by plenty of pastures available to the pregnant dams [6]. In case of AFC, calves born in the dry periods older 3 month of age than those born in rainfall though feed availability is relatively better in rainfall. Thus, from the results of this study it is evident that calves
born in the dry season perform better compared to those born in the other seasons than naturally bred cow (table 2). In the rainfall, animals grow well because of the higher quality and quantity of available feeds. However, during the dry periods, forage is not enough mostly in east java when the dry season becomes longer compared to rainy periods, which highly affects livestock productivity. All of these factors affect the reproductive performance of Ongole Cross cattle seriously.

The Mating system affected the AFC (table 2) significantly. This shows that artificial insemination has much influence on cow’s AFC. The present results are not in the same line with those found by Gunawan et al. [6] who found that type of mating had no differential effect on AFC in Bali cattle. However, this results is an agreement with Mwatawala and Kifaro [11], who found that artificially inseminated cows were different from naturally bred for AFC parameter. This study found that naturally bred cows were younger at calving by 1.1 months than those obtained by using artificial insemination. The difference between the average of age at first calving of artificially and naturally bred cows could be speculated as a result of high conception rate in naturally bred cows due to lack of uncontrolled crossbreeding between Ongole Cross cattle and exotic through Artificial insemination.

The prediction of Heritability for the age at first calving of Ongole Cross cattle was 0.28+ 0.04 (table 3) which is in line with Gunawan et al [3] who found that heritability estimated for AFC of Bali cattle was 0.26. However, the result of the present study is higher compared to those stated in the literature for tropical cattle. The present value of heritability on AFC is categorized as moderate 0.2-0.4 [12]. The moderate heritability estimation of AFC in this research indicated that there is a possibility for improving this trait through selection. AFC is an important economical as it is related to a productive life and lifetime productivity [13]. A reduced age at first calving will correlate to the number of calves born for a given number of the calf [13].

3.2.2. Calving interval. Calving interval was highly significant (P<0.01) influenced by only the type of mating but not by sex, year of birth, parity and season (table 2). Cow bred by artificial insemination resulted into different in the average of calving interval when compared to naturally bred cows. The present result is in line with the previous results found by Makgahlela et al [13] who found that naturally bred cows had calving interval differences compared to those bred using artificial insemination. The present research found that artificially bred cows tend to calve again about 19 days earlier than naturally bred. Gunawan et al. [6] found the same result that Bali cows mated naturally to Bali bulls had shorted CI than Bali cows artificially inseminated with exotic semen by 10 days. This significant effect of mating system on reproductive performance, especially in case of calving interval, may be due to conception period, including the ranch type of management, feeds, bulls used, and expertise in carrying out artificial insemination [11].

Results of heritability for CI of Ongole Cross cattle was 0.46±0.007 (table 3). Heritability value in the present research was classified to be in high category as it was higher than 0.4 [12]. Heritability for CI in the present research was higher compared to those found in the literature. Gunawan et al. [7] found 0.41 as the heritability of calving interval in Bali cattle. Javed et al. [14] found that 0.07 was the heritability for CI in Boran cattle exploited in Tropical conditions. Braga-Lobo [15] reported 0.14+0.01 as the heritability in Zebu cows. These are different due to the differences of breeds, models of statistical analysis (animal or sire models), selection pressure within the population, sample size, and environmental effect [18]. High heritability values of CI indicate that selection since traits on the basis mass selection will be effective to decrease CI in Bali cattle.

3.2.3. Days open. Days Open (DO) was significantly (P<0.01) influenced by the type of mating only but not by sex, year of birth, parity, and season (table 2). Cow bred through artificial insemination showed differences for the average of DO when compared to naturally breed cows (table 2). This study showed naturally breed cows tend to calve again about 3 days earlier than cows breed using artificial insemination. This should be explained by the superiority of naturally breed heifers over artificially breed cows. The feeding of low quality feeds during the dry periods influenced DO intervals to be longer due to the longer recovery period after calving.
Heritability estimation for days open of PO cattle was 0.21±0.04 (table 3). This value was much high when compared to those usually found in literature for tropical cattle. Ayalew et al. [16] reported heritability of days open in the same study was 0.09±0.03, 0.09±0.03, and 0.10±0.04 in Ethiopian Holstein. Shalaby et al. [17] estimated heritability of DO in Egypt Holstein was 0.19. The low heritability estimates found in the present research showed that DO were highly affected by temporary environmental factors, this was due to the complex nature of reproductive traits, difficulties in detection of oestrus, and various other managerial and nutritional factors [17]. The prediction of the heritability for DO is also an indicator of the presence of a genetic basis that deserves selection or culling of an animal. Differences found among the result of heritability estimation DO in this study might be due to breed differences, statistical analysis (animal or sire models), selection intensity within the population, number of samples and environmental effect [18].

4. Conclusion
The heritability estimates for reproduction traits AFC, CI, and DO showed that the environmental factors have much influence on those traits and minor effects from genetic factors. Type of mating was influence significantly to all reproductive parameters AFC, CI, and DO. With regard to AFC was influenced by not only type of mating, but also seasonal effects. Estimation heritability value and non genetic factors are an important strategic step in planning a breeding program which might be used as a tool for the implementation of selective breed improvement in a population of Ongole Cross cattle.

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