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Estimation of Genetic Superiority and Reproductive Performance of Dairy Cows at Different Rearing Locations

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ABSTRACT

The objective of this study was to estimate the genetic superiority using the estimated breeding value (EBV) and most probable producing ability (MPPA) and to elucidate the reproductive performance of dairy cows at two different rearing locations. This study used data from dairy cows in two areas, namely at the dairy breeding center (Group I) for 100 heads and the dairy farmers (group II) for 40 head cows. The survey method was used in this study. The parameters observed were total milk production, days open (DO), service per conception (S/C), and calving interval (CI). The data were analyzed descriptively and using a t-test. The results showed that productivity in groups I and II for the total milk production was 5,017.52±1,096.84 and 3,922.52±1,296.55 kg/head/lactation, respectively; DO was 141.45±64.30 and 281.68±92.42 days, respectively; S/C was 1.47±0.61 and 1.70±0.69 times, respectively; and CI was 421.59±63.47 and 565.23±95.33 days, respectively. In conclusion, differences in management systems in breeding center and dairy farmers group give different productivity. The results can be used for management improvement and increasing productivity strategies. Livestock selection in dairy breeding center and dairy farmers can be made by estimating the genetic superiority using the estimated breeding value and most probable producing ability.

Keywords: Dairy cows, breeding value, milk production, reproductive performance

INTRODUCTION

Dairy cows that developed in Indonesia generally are Friesian Holstein breed (FH). FH cattle breed has adapted well in the tropics, including Indonesia (Kurnianto, 2022). The dairy cow population in Indonesia is 578,579 heads with a fresh milk production domestic value of 962,676.66 tons (BPS, 2021). Fresh milk production in the country at this time has not been able to meet national milk needs, so the drawbacks still must be fulfilled by import. Smallholder farms contribute greatly to domestic milk production and the rest by livestock companies (Kurnianto, 2021). Genetic factors, the condition of the environment, and their interactions impact cattle productivity. Genetic factors are permanent, can be passed on to offspring, and influence milk production by 30% (Makin, 2012; Kurnianto, 2021). Environmental conditions both external and internal influence the nature of the cattle phenotype so that the performance of productivity of dairy cows can vary from one place to another location.

Milk production is a quantitative trait that can be measured to describe the milk productivity of cows. The relationship of milk production is close to reproduction. Management reproduction impacts efficiency reproduction, profit, and dairy production. First mating after calving, the number of mating per pregnancy, mating period, days open, and calving interval are a reproductive parameter that can be used for evaluating the performance of reproduction in female dairy cows (Prabowo, 2021). Productivity can be enhanced through the enhancement of quality genetics livestock, developing the business scale, repair management, and improving the dairy cow population. To get a dairy cow with high-quality genetic and reduce dependency on imported seeds so in the rearing group, the breeding process must be carried out by a method of selection and setting of mating. One of the sources of information that can be used for the selection process is a record from the performance of cattle (Kurnianto, 2021). Selection could be conducted by estimating the genetic superiority of cattle with the method of estimating breeding value and production ability. The estimation of breeding value could describe guess ability bequeath properties. Meanwhile, ability production or *Most Probable Producing Ability* (MPPA) is used to estimate the ability of milk production in the future (Indrijani *et al.,* 2018).

Selection based on genetic superiority is still seldom done in groups of farms. One of the causes is limitations records and height level

displacement of cattle. Based on these conditions, this study was conducted to estimate genetic superiority using estimated breeding value and ability production based on milk production, and for knowing the performance reproduction of dairy cows reared in two locations with different management maintenance. Research results could become a base for improving the management and selection of cows that adapt to Indonesia's natural environment conditions for productivity increase.

MATERIALS AND METHODS

The study was implemented in two locations with different management maintenance, namely group maintenance of breeding center in the National livestock dairy breeding and forages center Baturraden, Banyumas Regency, Central Java, and groups maintenance of dairy farmers in the Cangkringan District, Special Region of Yogyakarta. Materials used in this study were record of 140 heads of dairy cows (100 heads from dairy breeding center and 40 heads from dairy farmers group). The survey method used in this study. Election sample by *purposive sampling* with criteria dairy cows was born in Indonesia, has been calving at least 2 times, has milk production and reproduction records. Observed parameters are:

1. Total milk production is the amount of milk production produced by a dairy cow during lactation. In this study, this calculation was carried out during the period of the first lactation, using notes of once a month's milk production once, the result of morning and evening milking. Estimating milk production during lactation using the Test Interval Method according to the *International Committee for Animal Recording* (ICAR, 2011). Standardization of milk production was done with data correction using factors of correction for milking frequency, factor correction for lactation duration, and factor correction for mature equivalent (Kurnianto, 2022). Calculation corrected milk production calculated based on the method Dairy Herd Improvement Association of the United States Department of Agriculture (Komala *et al.,* 2015) with the formula:

Corrected milk production = Estimated milk production x FK_{ME} x FK_{LL} x FK_{FP}

Description:
FK_{ME}: Factor of correction for mature equivalent
FK_{LL}: Factor of correction for length of lactation that is to 305 days
FK_{FP}: Factor of correction for milking frequency

2. Estimation of breeding value and ability milk production.

   a. Estimation breeding value was calculated using a single measurement according to method Hardjosubroto (Supriyantono *et al.,* 2019), with the formula:

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

   Description:
   EBV = the estimation breeding value
   h^2 = value of heretability
   P_i = mean of production from individual
   $\bar{P}_p$ = mean of production from population

   b. Ability milk production was calculated based on the method from Warwick (Indrijani *et al.,* 2018) with the formula:

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

   Description:
   MPPA = *most probable producing ability*
   n = number of records
   r = value repeatability
   $\bar{P}$ = mean of production from population
   P = mean of individual production's cow

The heretability value used for milk production is 0.25, and the repeatability value for milk production is 0.50 (Kurnianto, 2022). Result data calculation of estimation breeding value and MPPA conducted sorting with results biggest occupy order top so that obtained order ranking. Test ranking individual based on EBV and ability milk production using correlation Spearman rank method, with the formula:

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

Description: r_s = coefficient correlation Spearman rank; n= number couple observed rating among one variable with another variable; d_i = difference rating from every observed pair.

3. *Days open* (DO) was the distance time among the date of first calving until the

insemination date occurs pregnancy (unit day).

4. *Service per conception* (S/C) was obtained with a count of artificial insemination made for produce the second pregnancy (unit times).
5. *Calving interval* (CI) was the date interval from the first calving to the second calving (unit day).

Data on milk production and reproduction were tabulated and analyzed by descriptive and t-test using the SAS (Statistical Analysis System) program to know the difference between groups. The mean, standard deviation, and coefficient of diversity were calculated for each parameter. Average or *mean* calculated with the formula: $\bar{X} = \frac{X_1+X_2+\cdots+X_n}{n}$

Description:
$X_1, X_2 \ldots, X_n$ = size each individual in sample
$\bar{X}$ = sample mean
n = number observation sample

Standard Deviation calculated with the formula:

$$s = \sqrt{\frac{(X_1 - X)^2 + (X_2 - X)^2 + \cdots + (X_n - X)^2}{n-1}}$$

Description:
n = number observation sample
x_n = result observation to-n
s = standard deviation

Coefficient of diversity was calculated with the formula $C = \frac{s}{\bar{X}} x\ 100\%$
Description:
C = Coefficient of diversity
s = standard deviation
$\bar{X}$ = average

Category of diversity: <5% = low diversity, 6-14% = medium diversity, 15% = high diversity.

RESULTS AND DISCUSSION

Description Condition General and Management at The Study Location

The study was implemented in two groups of rearing locations with different management. Group I was a maintenance breeding installation in the National livestock dairy breeding and forages center Baturraden belonging to the Ministry of Agriculture. Located on the plains tall slope of Slamet Mountain in the Banyumas Regency, Central Java Province. On this location, cow was maintained by an intensive cage model *free stall* and *semi-free stall*. Cows were placed based on their physiological status. Milking was conducted twice a day using machine milk. Cow mating was carried out by inseminator officers using the method of artificial insemination. The feed was given in the form of forage (grass and legumes) and concentrates in TMR form (*total mixed ratio*). Drinking water was given by *at libitum.* Group II was a group of dairy farmers located on the tall slope of Mount Merapi, Cangkringan District, Special Region of Yogyakarta. Maintenance cow with a tie cage model, most of which were placed in groups in a colony shed, and individual keeps some. A group farm was combined of several farmer cow milk. Placement of cow in the barn based on ownership from a farmer.

Milking was conducted twice a day manually by owner cattle. Cow mating with artificial insemination method done by inseminator service or cooperative officer. The feed was given in the form of forages (grass, legume, or straw) and concentrates. The concentrate given by each farmer in the group is the same because provided by a local cooperative dairy farm. Drinking water was given by *at libitum.* The environmental conditions of the study location are served in table 1.

Table 1. Location research in group I and group II.

Aspect	Location Maintenance	
	Group I	Group II
Altitude (masl)	700-750	600-700
Temperature (ºC)	18-28	18-24
Humidity (%)	70-80%	64-78%

Group I: Dairy breeding center in the Banyumas District, Group II: Dairy farmers group in the Sleman District

Composition cattle in both groups consist of lactation cow, cow period dry, heifer, and calf. The recording pattern already applied in both groups uses notes on a sheet card/book and

is stored by a computer by officer recording. Records in traditional dairy farmers are not yet everything conducted with fine, so for knowing complete information from an individual must collect data from many sources like recorder cooperatives, inseminators, and owners' cattle.

Milk Production

Calculating of total milk production was carried out using records periodically once a month on one lactation and done data standardization by the correction factor. Standardization of milk production was carried out to increase precision in estimating production with reduced Variations caused by non-genetic factors such as lactation duration, frequency of milking, and age at calving (Santosa *et al.,* 2014).

Table 2. Performance of milk production milk based on rearing location

Parameter	Group I (n=100)		Group II (n=40)	
	Mean± Standard Deviation	Coefficient of Diversity (%)	Mean± Standard Deviation	Coefficient of Diversity (%)
Corrected milk production one lactation (kg/head/lactation)	5,017.52±1,096.84 [a]	21.86	3,922.52±1,296.55 [b]	33.05
Daily milk production (kg/head/day)	16.45 ± 3.60 [a]	21.86	12.86 ± 4.25 [b]	33.05

Description: Group I: Dairy breeding center, Group II: Dairy farmers group. Value in one line with different superscript show a significant difference at level 95% ($p<0.05$)

The results showed that the mean of total milk production in group breeding center (5,017.52±1,096.84 kg/head/lactation) was higher and significantly different ($P<0.05$) compared to group II (3,922.52±1,296.55 kg/head/lactation). Coefficient of diversity in both groups, including category high, where the coefficient of diversity in group II is taller than group I. The high coefficient of diversity describes the diverse nature the still enough for high and effective conducted selection in a population. There was no different in milk production in another study: 5,992,76±110,28 kg/head/lactation at PT. UPBS (Rahman, 2015), 4553.20±1111.41 kg/head/ lactation at BPPIBTSP Bunikasih (A'ini *et al.,* 2021), 4185.89 ±990.43 kg/ head/lactation on farms people in West Java (Makin, 2012) and 4,175.9±980,33 kg/head/lactation in Pacitan (Prabowo, 2021).

The difference in total milk production of the two groups occurs because of differences in the environment and management applied, in addition to factor genetics. Milk production is influenced by the duration of lactation and the age of calving (Santosa *et al.,* 2014), as well as factor environments like feed, drinking water, milking interval, cage, and location maintenance (Pasaribu *et al*., 2015; Setyorini *et al.,* 2020). Feed is an environmental factor that has a major influence on cattle productivity because milk production is influenced by the quality and quantity of feed consumed (Supriadi *et al.,* 2017; Kusmayadi *et al.*, 2018).

In the breeding center, feed given uses a TMR system with sufficient quality and quantity for needs cow milk, as well given by officer special follow the applicable SOP. In dairy farmer location, there were already standard feeding, however, they still vary in feeding depending on the ability of each farmer. Rearing location affects milk production because of the difference in altitude, temperature, and humidity. Condition non-ideal environment can cause existence stress that affects effort adaptation livestock and changes the physiology and productivity of livestock (Setyorini *et al*., 2020).

Estimation of Breeding Value and Ability of Milk Production

Estimation of breeding value and ability production or *Most Probable Producing Ability* (MPPA) in the population can be conducted to estimate superiority genetics for selection cattle. *Estimated breeding value* (EBV) results in group breeding center showed as many as 57 cows had an EBV of value positive (57%) and 43 cows (43%) worth negative, with average ability milk production of 5017.52 kg. Whereas, in dairy farmers group shows 18 cows had a positive breeding value (45%) and 22 cows with negative breeding values (55%) with average milk production of 3,922.52 kg. Estimated results of breeding value and Most Probable Producing Ability are presented in table 3.

Table 3. Result of Estimated Breeding Value and Most Probable Producing Ability (MPPA) based on rearing location

Group	Rank	No Code Cattle	Estimated Breeding Value	Estimate Ability Milk Production (kg)
I	1	I.97	723.09	6463.70
	2	I.31	593.53	6204.57
	3	I.34	525.71	6068.94
	4	I.87	471.88	5961.28
	5	I.98	435.90	5889.31
	6	I.95	418.33	5854.17
	7	I.17	367.31	5752.14
	8	I.28	342.83	5703.17
	9	I.86	319.24	5655.99
	10	I.47	309.57	5636.66
	…	…	…	…
	99	I.66	-752.63	3512.26
	100	I.84	-845.71	3326.09
II	1	II.17	974.89	5872.31
	2	II.16	876.08	5674.69
	3	II.22	654.33	5231.18
	4	II.39	447.80	4818,12
	5	II.14	371.09	4664.70
	6	II.1	348.23	4618,98
	7	II.3	237.25	4397.03
	8	II.8	189.20	4300.93
	9	II.23	118.51	4159.54
	10	II.28	98.78	4120.09
	…	…	…	…
	39	II.24	-327.08	3268.36
	40	II.19	-546.92	2828.69

Description: Group I: Dairy breeding center group, Group II: Dairy farmers group

Cow with number code cattle I.97 was ranked 1st in group I, and cattle with number code livestock II.17 was ranked 1st in group II were cattle with estimation score breeding and best probable producing ability between the observed population in the group. Cow with positive breeding value and MPPA above production average population have genetic superiority and can be maintained in the selection process and are expected could produce descendants with good productivity. At the same time, cattle with low breeding value and MPPA could be recommended for conducted expenditure cattle.

The breeding value of 723.09 and ability production of 6463.70 means cow the expected could bequeath higher milk production compared to the average population of 723.09 kg in generation next and estimated ability milk production by cows that in the future or next period of 6463.70 kg. Ability milk production declared in calculated MPPA value by absolute that is relative MPPA estimate added with average group milk production. The Most Probable Producing Ability value is affected by the average population, individual milk production, the quantity of lactation from the individual cow, and repeatability. Variation score repeatability of a trait in the population can be due to the influence of diversity environment permanent and covers diverse environment temporarily like nutrition, climate, and management maintenance (Aditya, 2015).

Accuracy estimating genetic superiority uses the estimation breeding value and estimation Most Probable Producing Ability

method calculated using correlation test Spearman's Rank. Analysis results to rating whole cattle with two methods guess on both groups showed a coefficient correlation of 1 and includes category correlation very strong (P<0.01). Based on the results, breeding value and Most Probable Producing Ability give results the same rank; only different score estimates, so both the methods can be used for estimating superiority genetic in the female dairy cows.

Estimated results breeding value and Most Probable Producing Ability only apply to livestock in the population studied. Selection with chosen candidate superior parent expected to have ability bequeath potency genetics in offspring and production lactation next. The mating program is conducted by choosing the male with more high potential so that the expected productivity of cattle derivatives will be better.

Reproductive Performance

Description means and standard deviation of performance reproduction in two rearing locations are served in table 4.

Table 4. Reproduction of dairy cows based on rearing location

Parameter	Group I (n=100)		Group II (n=40)	
	Mean±Standard Deviation	Coefficient of Diversity (%)	Mean±Standard Deviation	Coefficient of Diversity (%)
Days open (days)	141.45±64.30 [a]	45.45	281.68±92.42 [b]	32.81
Service per conception (times)	1.47±0.61	41.50	1.70±0.69	40.59
Calving interval (days)	421.59±63.47 [a]	15.05	565.23±95.33 [b]	16.87

Description: Group I: Dairy breeding center, Group II: Dairy farmers group. Value in one line with different superscript show a significant difference at level 95% (p<0.05)

Research results showed average *days open* (DO) in the breeding center (141.45±64.30 days) were lower and significantly different (P<0.05) compared to the dairy farmers group (281.68±92.42 days). DO number in this study was almost the same as several studies previously, namely 202.45 ± 165.84 days in Jabung Malang (Wahyudi *et al.*, 2013), 260.63±147.04 days in West Sumatra (Reswati *et al.,* 2014), 117.10±30.52 days smallholder farm in Pacitan (Prabowo, 2021), 169±70.46 days at Ciawitali Farm Bandung (Christi *et al.,* 2022), 218.9±58.7 days at PT Greenfields (Ananda *et al*., 2019), and 150,06±56.88 days in Garut (Kusmayadi *et al*., 2018). DO delay is affected by several factors, including first mating after calving, too late lust, error detection lust that causes late insemination, healthy cattle, and factor environment. The dairy cow that has high milk production potential experience lateness lust because height needs energy and distraction work hormones in the body (Wahyudi *et al.*, 2013). Feeding nutrients in the postpartum phase can also affect DO because of its effects on the hormonal system of cows. In the dairy farmers group, DO more likely caused observation postpartum lust that hasn't been intensive because part location cages the location far apart from the farmer's house.

The value of *service per conception* (S/C) showed the fertility of the cow. S/C on group breeding center (1.47±0.61 times) was lower than group II (1.70±0.69 times), although not significantly different. S/C in both groups belongs good to compare other studies, namely 3.2±1.8 times in PT Greenfields (Ananda *et al*., 2019), 2.93 ± 1.73 times in the Jabung Malang (Wahyudi *et al.,* 2013), 1.7 times on farm people in Boyolali (Wicaksono *et al.,* 2018), 3.01±2.34 times at Ciawitali Farm Bandung (Christi *et al*., 2022) and 2.21 ±0.58 times at smallholder farm in Garut (Kusmayadi *et al*., 2018). Related S/C with detection lust, execution insemination artificial (IB), and accuracy IB time (Wicaksono *et al.,* 2018).

The calving interval (CI) was one of the indicators of efficient reproduction. CI in group I was lower and significantly different (P<0.05) compared to group II (421.59±63.47 days vs. 565.23±95.33 days). CI in both groups exceeded the ideal calving interval, i.e., 12 months (Wahyudi *et al.,* 2013); however not far different from several studies previously reported CI figures of 434.9±58.9 days at PT Greenfields (Ananda *et al.,* 2019), 404.4 days at UPTD BPPIP-TSP Bunikasih (Sembada *et al.*, 2020), 432.06±56.49 days on the smallholder farm in Garut (Kusmayadi *et al.*, 2018), 461.74±152.37 days in Jabung Malang (Wahyudi *et al.,* 2013),

and 548.63±168.3 days in West Sumatra (Reswati *et al.,* 2014). The length of the CI is affected by the *days open,* and S/C also influences cost maintenance cattle. Long CI numbers show low-efficiency reproduction cattle (Kusmayadi *et al.*, 2018). Improvement of management rearing can be conducted through recording, more intensive lust detection, and enhancement of feed quality, especially postpartum phase for needs milk production and maintenance balance reproductive hormonal system.

CONCLUSION

The results of the study can be concluded that: (1) differences in management systems in the dairy breeding center and the dairy farmers give different productivity. (2) The results of this study can be used as a base for improving management maintenance and design strategy enhancement productivity in the dairy breeding center and the dairy farmers. (3) Selection of cattle in the herd can be conducted using estimated breeding value and most probable producing ability.

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