Milk Production Curve on Various Test Day Patterns (Case in BBPTU-HPT Baturraden)

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Abstract. Information about milk production in dairy cows is obtained most accurately by daily recording, but with consideration, such as time and cost. This study aimed to obtain accurate and efficient recording patterns to estimate milk production in dairy cows. This research used recording of milk production in BBPTU-HPT Baturraden. The data used is the record of milk production of Test Day (TD) from the year 2014-2017 as many as 8696 records of TD milk production that derived from 213 head of cows on first lactation. The record of TD milk production is the recording of milk production performed only on certain days during a lactation period. The milk production expectant curve used is the Ali-Schaeffer. The result of this research that Ali-Schaeffer equation with correlation between estimated and actual value (r) 0.991, standard error (se) 0.64, and standard deviation (stdv) 0.01. Recording of milk production Pattern 5, namely the recording of milk production in TD 1, 2, 5, 8, and 11, showed the highest correlation value (r=0.998). It is recommended to record the milk production in the early months of lactation and combined with the recording of TD milk production periodically every three months, from mid to late production.

1. Introduction
Information on milk production in dairy cattle, obtained most accurately with daily recordings, but with a variety of considerations, including time and cost, then now generally record milk production done periodically during lactation. Cumulative milk production recording can be done weekly, biweekly, monthly, bimonthly, or trimonthly. Another recording system that is now widely use in the world is Test Day (TD), which is the recording of milk production only on certain days in one lactation period. TD recording system is different from the system of recording cumulative milk production. In cumulative recording, for estimating total milk production, daily production is multiplied by the number of recording time intervals, whereas in TD recording, to estimate total milk production, it is not necessary to multiply the milking day interval, but simply by using curves.

TD recording can be done in two ways, recorded on the same date or on the same production day. That TD can be made into various recording combinations, so that from various combinations of TD recording patterns will be obtained a simple TD record pattern, but quite accurate to prediction of milk production. The recent TD record attracts many parties, as it is more flexible in handling records derived from different recording patterns, and is cheaper when compared to cumulative records, especially for large companies demanding more efficiency.

Milk production in dairy cattle forms a certain curve that has the same tendency, which is increased at the beginning of production, then reaches its peak and then decreases until the end of production. An accurate dairy milk dairy production curve can be used to determine the total of milk production at certain time based on production records. In Indonesia, until now, there are only few farmers who record milk production, even if the recording is generally incomplete. Incomplete records will make it difficult to predict milk production during a lactation period, so it is worth looking for the right milk
production curve to predict it.

Ali and Schaeffer [1] have studied three milk production curves in first lactation and the results of the correlation are as follows: Gamma 0.88, IQP 0.87, and Ali-Schaeffer regression 0.95. Pallawarukka (1989) used gamma curves and non-linear curves to estimate the production of FH in Wisconsin from various recording systems. Jamrozik [2] obtained the correlation results for the Ali-Schaeffer curve of 0.975, Wood of 0.951, and Wilmink of 0.953. The results of the study of Dimauro [3] showed that from 13,925 recorded of milk production, which had a determination above 80%, 49.8% for the Wood curve; 48.8% for the Wilmink; 62.8% for the Ali-Schaeffer; and 60.9% for the Legendre Orthogonal Polynomial. So based on the results of the study, it can be conclude that the milk production curve from Ali-Schaeffer is more accurate in estimating milk production in dairy cattle.

Estimating milk production curves requires simultaneous and complete milk production records. One of the agencies that can meet these data needs is Balai Besar Pembibitan Ternak Unggul dan Hijauan Pakan Ternak (BBPTU-HPT) Baturraden. The BBPTU also functions as a place for assessment and dissemination of livestock technology and as a technical research center for livestock and has a good recording system, so that it can support the research that will be carried out. Based on this information, it is necessary to do research on estimation of milk production curve in various patterns of recording of Test Day (TD). The results of this study are expected to obtain accurate and efficient recording patterns to estimate milk production in dairy cattle.

2. Materials and Methods

2.1. Materials

This study used milk production record of dairy cattle at the BBPTU-HPT Baturraden. The data used are TD milk production records from 2014-2017 as many as 8,696 records of TD derived from 213 female cows on first lactation. The complete data required as follows:
1. Livestock identity data: cattle number, age of cattle, time of calf birth
2. Records of TD milk production based on certain milking days.

2.2. Method

The research used case study at BBPTU-HPT Baturraden. Data analysis using regression and correlation. Determination of livestock data retrieval using purposive sampling with consideration of the availability of data on milk production at the first lactation and has the required data completeness.

Records of daily milk production (test day/TD) are recorded twice a day, i.e. in morning milking and afternoon, so that daily milk production is total milk production as a result of the sum of milk production in morning and afternoon milking. In this study milk production record required on certain days, that is as follows: TD 1 is milk production recorded on milking day 5th, TD 2 day 35th, TD 3 day 65th, TD 4 day 95th, TD 5 day 125th, TD 6 day 155th, TD 7 day 185th, TD 8 day 215th, TD 9 day 245th, TD 10 day 275th, and TD 11 day 305th.

Daily record data collection was carried out starting on day 5th with the assumption that in the previous days, colostrum milk produced by dam was given to calves and it was expected that production would be relatively stable at that time. Recording is done with an interval of 30 days, this is done to simplify data processing and make it easier for farmers to apply the results of this study.

TD milk production is made into several patterns, some are simultaneous and some are periodic as follows:

1. Pattern 1: Complete TD records (TD 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11)
2. Pattern 2: Odd TD records (TD 1, 3, 5, 7, 9, 11)
3. Pattern 3: Even TD records (TD 2, 4, 6, 8, 10)
4. Pattern 4: TD records 1, 2, 3, 5, 7, 9, 11
5. Pattern 5: TD records 1, 2, 5, 8, 11
6. Pattern 6: TD records 1, 2, 3, 7, 11
7. Pattern 7: TD 1, 2, 6, 10

2.3. Test of Milk Production Accuracy with Ali-Schaeffer Regression Equation
Non-linear regression analysis using SAS software 9. Accuracy is seen from the correlation between the estimated values and the observations (r) and standard error (SE). The estimator equation of milk production curve used is Ali-Schaeffer regression as follows:

\[ y = a + b \frac{t}{305} + c \left( \frac{t}{305} \right)^2 + d \left( \ln \frac{305}{t} \right) + e \left( \ln \frac{305}{t} \right)^2 \]

- \( y \) = Milk yield predicted
- \( t \) = DIM (Day Interval Milk) = 5, 35, 65, ..., 305
- \( a, b, c, d, e \) = regression coefficient

3. Result and Discussions

3.1. Data Description
TD milk production is the amount of milk production taken on certain days. This milk production is the result of the addition of milk production in the morning and afternoon milking that is done on the same day. The results can be seen in Table 1.

| Test Day (TD) | Milking day (day) | Amount of data (n) | Actual Milk Production (kg) |
|---------------|-------------------|--------------------|-----------------------------|
| TD 1          | 5                 | 1174               | 17.47                       |
| TD 2          | 35                | 2645               | 20.71                       |
| TD 3          | 65                | 2304               | 21.08                       |
| TD 4          | 95                | 1264               | 18.08                       |
| TD 5          | 125               | 776                | 17.12                       |
| TD 6          | 155               | 259                | 14.16                       |
| TD 7          | 185               | 126                | 14.06                       |
| TD 8          | 215               | 96                 | 12.44                       |
| TD 9          | 245               | 20                 | 11.86                       |
| TD 10         | 275               | 17                 | 11.19                       |
| TD 11         | 305               | 15                 | 10.65                       |

In general, the level of milk production of dairy cows will increase at the beginning of lactation to the peak of production, and then will decrease slowly to low production. Based on the description of milk production data in Table 1, the average milk production increased from TD 1 to TD 3 (milking day 65th), and then continued to decrease until the end of lactation at TD 11 (milking day 305th). Generally dairy cow will be dried up (no longer milking) at the end of lactation or about two months before to the next partus.

The result of this research get the average of TD milk production on first lactation period at BBPTU-HPT Baturraden equal to 15.35 kg. Milk production average is higher when compared with the average production of TD milk lactation in the same place in the year 1997-2005 as much as 12.24 kg [4], 2006-2011 as much as 12.91 kg [5], and 2006-2013 as much as 12.99 kg. Increase in production from year to year may be possible due to the selection process of dairy cows conducted by BBPTU.
3.2. Estimating Milk Production Curves

Based on the calculations using of SAS 9 software, we obtain the coefficients needed to complete the equation of Ali-Schaeffer milk production estimator, which will be tested for accuracy with actual TD milk production. The formula as follows:

\[ y = 43.22 - 56.20 \left( \frac{t}{305} \right) + 23.88 \left( \frac{t}{305} \right)^2 - 8.92 \left( \ln \frac{305}{t} \right) + 0.70 \left( \ln \frac{305}{t} \right)^2 \]

The next statistical analysis is find the correlation value. The curve equation accuracy will be based on the correlation between the expected value with the actual result (r) and the standard error (se). The results showed that this equation can be used to estimate milk production, because it has a correlation between the estimated value with the actual value (r) of 0.991 with the standard error (se) 0.64. The standard deviation (stdv) between actual milk production and the allegation of 0.01 as can be seen in Table 2.

| Test Day (TD) | Milking Day (day) | Actual Milk Production (kg) | Predicted Milk Production (kg) | Deviation (kg) |
|--------------|-------------------|-----------------------------|-------------------------------|---------------|
| TD 1         | 5                 | 17.47                       | 17.45                         | 0.02          |
| TD 2         | 35                | 20.71                       | 21.06                         | -0.35         |
| TD 3         | 65                | 21.08                       | 20.22                         | 0.87          |
| TD 4         | 95                | 18.08                       | 18.58                         | -0.50         |
| TD 5         | 125               | 17.12                       | 16.80                         | 0.32          |
| TD 6         | 155               | 14.16                       | 15.11                         | -0.95         |
| TD 7         | 185               | 14.06                       | 13.64                         | 0.43          |
| TD 8         | 215               | 12.44                       | 12.44                         | 0.00          |
| TD 9         | 245               | 11.86                       | 11.57                         | 0.29          |
| TD 10        | 275               | 11.19                       | 11.05                         | 0.14          |
| TD 11        | 305               | 10.65                       | 10.90                         | -0.25         |

Observing the increase or decrease in milk production based on the TD record, it would be easier if the available data is made into curve form, as can be seen in figure 1. Generally milk production follows a regular pattern on each lactation. Milk production will rise for 45\(^{th}\) to 60\(^{th}\) days after the cow are partus until it reaches the peak of production and then slowly decreases until the end of lactation. In this study, peak production is generally achieved between the first and second months and continues to decline until the end of the lactation.

Atabany [6] results, the maximum milk production occurs at the beginning of the lactation and minimum milk production occurs at the end of the lactation. The maximum and minimum milk production of this research at BBPTU Baturraden, showed that the peak of Friesian Holstein (FH) cow’s milk production occurs at week 2\(^{rd}\) to 5\(^{th}\). This opinion is supported by research conducted at PT. Taurus Dairy Farm, Cicurug-Sukabumi that the peak of milk production occurs in the range of week 2\(^{nd}\) to 5\(^{th}\) [7].
The results show that the shape of the Ali-Schaeffer equation curve almost same with the plotting of actual TD milk production data, only a few deviations on the day 65th of milking (TD 3), 95th (TD 4) and 155th (TD 6). This showed that visually based on plotting data, Ali-Schaeffer's equation curve is a good estimator curve. Furthermore, this alleged milk production will be used to test the correlation between several different TD recording patterns which results can be seen in Table 3.

### Table 3. Correlation of Test Day (TD) Milk Production

| Recording Pattern | Test Day Record (TD pattern) | Correlation |
|-------------------|------------------------------|-------------|
| Pattern 1         | Complete                     | 0.991       |
| Pattern 2         | Odd                          | 0.997       |
| Pattern 3         | Even                         | 0.995       |
| Pattern 4         | 1, 2, 3, 5, 7, 9, 11         | 0.995       |
| Pattern 5         | 1, 2, 5, 8, 11               | 0.998       |
| Pattern 6         | 1, 2, 3, 7, 11               | 0.994       |
| Pattern 7         | 1, 2, 6, 10                  | 0.993       |

Simultaneous or periodic TD recordings show a high correlation, it means all of these recordings can be applied. Complete TD recording requires more costs because milk production should be recorded every month, as well as the physiological trait of livestock are not the same. This will cause unequal production fluctuations and variations, especially during peak production in the second month (TD 3), and when production begins to decline in the third to fifth months (TD 4, 5 and 6). Milk production in the following month is relatively stable decrease form linear function.

The selection of recording patterns is based on the magnitude of the correlation between actual production on a certain time and its prediction. The results showed the recording of milk production Pattern 5, namely the recording of milk production in TD 1st, 2nd, 5th, 8th, and 11th showed the highest correlation value. Pattern 5 can be recommended to be done in smallholder farms that have difficulty recording milk production every month, or livestock companies that have large livestock for the purpose of efficiency.

Other research results to estimate milk production by using Gamma function can be done on a few months only. The recommended combination is the recording of milk production at month 4th and 5th or 4th and 6th, as well as 1st and 8th lactation months combined with record of month 2nd, 3rd, or 4th. The smallest estimate is combinations 3rd and 8th monthly recording or 1st, 3rd and 8th [8].

Test Day Model (TDM) has become the world standard and is widely adopted by various countries with various modifications in the genetic quality evaluation program on a regular basis [9, 10, 11, 12, 13, 14], especially for countries with diverse recordings of milk production, such as in Kenya [15]. In Indonesia, the problem is almost the same, that is the variety of recording system and the absence of
so that the use of TDM not only become a thing to be considered but has become a requirement in evaluating milk production in dairy cow, so that recording of milk production Pattern 5 can be solved that problem.

4. Conclusion
The Ali-Schaeffer equation can be used to estimate milk production by correlation between the estimated value with the actual value \( r = 0.991 \), the standard error \( \text{se} = 0.64 \), and standard deviation \( \text{stdv} = 0.01 \). Recording of milk production Pattern 5, namely record milk production on Test Day (TD) 1, 2, 5, 8, and 11, showed the highest correlation value \( r = 0.998 \).

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