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Review

Lactation Length Adjustment of Milk Yield Records

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ABSTRACT

The importance of lactation length adjustment in milk yield data from cattle and buffalo has been highlighted. Various methods of lactation length adjustment have been reviewed concluding that last test day procedure of adjustment is more accurate and that precision of predicting lactation milk yield can further be improved if average daily yield for the known past of the lactation is added among the predictors. As test day models are being adopted in most of the dairy cattle production set ups in different countries, need for the development of such models for buffaloes and cows under Pakistani conditions has been pointed out.

Key Words: Milk yield; Lactation length; Cattle; Buffalo

Incomplete lactation records are traditionally extended to a 305-day basis. Inclusion of such extended records reduces the bias in estimating breeding values of sires due to differences in the culling rates among the progeny groups. Early estimates of sire's breeding values by extending lactations in progress can help to reduce the generation interval as well as increase the intensity of selection. Preliminary indexes based on all available test-day yields of daughters to estimate breeding values of bulls have been used (Danell, 1982). This helps to identify the daughters of the young bulls that rank high to make extra measurements while sufficient numbers of their daughters were still in mid-lactation. Projected records are also used to estimate what cow will produce in a lactation while her lactation is still in progress. This early information can facilitate the farmer to decide if she should be kept for producing the offspring. Further, it helps in the allocation of resources such as feed supplies both for an individual cow and the herd. Various aspects of lactation length adjustment of production records are reviewed in the following paragraphs.

Lactation length adjustment. Yields are usually recorded monthly and 305-day lactation yield is calculated by linear interpolation between the monthly records. Earlier reports dealing with the accuracy of estimating lactation yield from samples taken at different intervals were reviewed by McDaniel (1969). He concluded that monthly sampling produced estimates within 5% of actual yield and that error of estimation increased as the length of sampling intervals increased. Many recent studies have also reported an increase in bias with increased testing interval. Anderson *et al.* (1989) estimated lactation milk yields by using sampling intervals spaced equally at 3, 7, 14, or 30 days, and unequally (six methods), based on relative emphasis on peak production period (15 to 90 days after calving). Although, all methods tended to overestimate the actual yield, sample biases were insignificant for all equally spaced methods. Accuracy and precision were both reported to increase when sampling was done more frequently. The conventional 30-day equal interval sampling procedure was reported to give acceptable estimates of total lactation milk yield.

Methods of projection. Various methods of extending partial records have been used in the past. The ratio-method was used earlier (Lamb & McGilliard, 1960, 1960a; Van Vleck & Henderson, 1961b; Syrstad, 1964; Lamb & McGilliard, 1967) to develop multiplicative adjustment factors. The ratio of 305-day milk yield and part-lactation yield at any stage of lactation were calculated and method was popular for its simplicity. The projection factors employed by USDA in 1965 were ratio factors by breed for two ages of freshening (McDaniel *et al.*, 1965). The season of calving was however, ignored to make the adoption of these factors easier for the dairy record processing centers (Wiggans & Van Vleck, 1978).

Multiple linear regression techniques have also been used (Madden *et al.*, 1959, Van Vleck & Henderson, 1961a; 1961b; Appleman *et al.*, 1969) to estimate 305-day yield from test-day yield. The prediction errors were generally smaller from this method as compared to ratio-method. Van Vleck and Henderson (1961a) found that multiple regression was accumulated yields but intra-herd multiple regression could increase the precision up to 20% as compared to the regression ignoring herds. Appleman *et al.* (1969) reported that multiple regression method accounted for up to 8% more variation than the ratio estimators. A least square model was used in this study to derive extension factors to predict completed records from partial records. The drawback of this multiple regression method, that it depended on constantly correct averages for complete and part lactations, was overcome by a modified regression approach. Lactation averages and phenotypic correlations between different parts of lactation and total lactation were the necessary parameters to predict 305-day lactation yields. Miller *et al.* (1972a) showed that this method had smaller error variance and less prediction bias than the ratio method. For projecting yield from first test, average absolute difference from the actual 305-day yield was reported to be 500 kg smaller for the modified regression procedure as compared with the estimates from ratio method.

Miller *et al.* (1972b) compared ratio factors, multiple regression, modified regression, and regression of the remainder of the lactation on last test. They concluded that records could be more accurately extended if the production on the last sample day rather than the cumulative yield was used to predict the unknown remaining yield. Later, Auran and Mocquot (1974), and Mocquot and Auran (1975) agreed with these findings. They however, proposed that multiplicative ratio factors could be used instead of regression of the remaining part of of the lactation on the last test day. Dommerholt (1975), Auran (1976), and Suzuki and Mitsumota (1976) all confirmed that method of estimating lactation yield by using the regression on the last test-day yield was a more reliable method to predict total lactation yield.

Information on proportion of net energy from concentrates was found unimportant in the study of Wiggans and Van Vleck (1978). Herd average production was, however, indicated to improve the accuracy of predicting 305-day yield from part records. Wiggans and Van Vleck (1979), and Wiggans (1980) also confirmed that the last test day was the best single predictor of the production from end of the partial record to 305-days. Herd average yield was reported to improve prediction for short lactations. Wiggans and Van Vleck (1979) used 364,328 production records to estimate unknown yield from last sample day production to 305-days. Separate factors were developed to extend the records on the basis of last sample day production for six calving seasons of two months each, three herd production levels (<5900, 5900 to 7000, and >7000 kg), and four age at calving groups (<34, 34 to 48, 49 to 60, and >60 months). First 65 days and last 60 days of lactation were not fit adequately by the function presented.

Wiggans (1980) used sample day records of 15,086 cows to estimate 305-day yield. Predictors of yield from the last test day to 305-days included average daily known yield, sample day yield, 305-day ME herd average yield, and days from last reported breeding to last sample day. Herd average was reported to increase accuracy for records of fewer than 125 days. Days since bred, used to account for the effects of pregnancy was found important in improving accuracy for records of more than 55 days but due to possibility of inaccurate and incomplete recording, was suggested not to be included among predictors. Inclusion of conception data did not appreciably increase the accuracy of prediction of adjustment factors based on last test day yield and predicted lactation length in the study of Bar-Anan *et al.* (1986). Last test day yield was found to be the most important factor in predicting annualized milk and fat yield. The multiplicative correction factors developed for buffaloes (Khan, 1986) and been re-evaluated by Khan (1996) and deficiency of the procedure has been highlighted in the presence of better models.

Wilmink (1987a) reported that single regression, multiple regression and factor analysis achieved similar accuracies for predicting 305-day milk yield. For parities 1, 2, and >2, when the last test-day yield was known at 50 days postpartum, correlation between predicted and actual 305-day yield were .87, .88, and .88. The single regression method, that uses the last known test-day yield was recommended for its simplicity.

The method used by USDA for projecting 305-day milk yield from partial performance involves regressing average daily yield in the later stages of lactation on measures of yield in early lactation (Wiggans & Powell, 1980; Wiggans & Dickinson, 1985). Predictors of future daily milk yield include days in milk for the partial record, herd average milk yield (mature equivalent), and last test day yield. For records with 155 days in milk or more, the ME herd average is not included in estimating the average daily milk yield. Completed records of cows discontinuing lactation before 305 days but remaining in the herd are also extended. This is due to higher heritability and repeatability of milk yield when all such records are extended (Norman *et al.*, 1985).

Exponential functions have also been used to describe lactation curves (Wood, 1967; Schaeffer *et al.*, 1977; Congleton & Everett, 1980a, 1980b; Rao & Sundaresan, 1980; Grossman *et al.*, 1986; Grossman & Koops, 1988). A non-linear model was proposed by Schaeffer *et al.* (1977) for predicting 305-day lactation yield in Holsteins and Jerseys. This method was reported to be at least as accurate as either the multiplicative factors or regression method. Both ratio and regression methods were more suitable in terms of smaller prediction errors than the gamma or inverse polynomial functions for estimating 300-day yields from part records (Rao & Sundaresan, 1980). The ratio method was, however, preferred over regression method due to its simplicity. Congleton and Everett (1980a) found that use of the incomplete gamma function to predict 305-day cumulative yield from partial records had smaller root mean squares (356 to 586 kg) than the test interval method with extension factors (396 to 751 kg). Incomplete gamma functions were found comparable for predicting 305-day yield with test interval and centering day techniques when monthly observations of daily milk yield were available for the entire lactation (Congleton & Everett, 1980b). Conflicting results found in these studies may be due to the degree of sophistication of the models used (Danell, 1982). Grossman and Koops (1988) has suggested using a diphasic function over incomplete gamma and monophasic functions to describe lactation curves. Suggestion was based on smaller, more symmetric, and less correlated residuals with diphasic functions than with incomplete gamma or monophasic functions to describe milk yield.

Iqbal (1996) recently developed projection factors for six prediction methods to test their accuracy for ranking buffaloes. The six prediction methods were: ordinary ratio method, ratio factors from last test day method, simple regression, modified regression, multiple regression and last test day regression method. Last test day regression method found better in terms of higher correlation coefficients between predicted and actual yield, zero bias and minimum variance of bias. Multiple regression method was the second best. Akram (1997) further tested the last test day procedure to see the feasibility of once a day recording. Four recording plans viz. AM plan (recording milk yield in the morning only), PM plan (recording milk yield in the evening only), alternate AM-PM plan (for the first month morning milk yield recorded, followed by alternate recording of evening and morning milk yields), alternate PM-AM plan (for the first month evening milk yield was recorded, followed by alternate recording of morning and evening milk yields) were compared for accuracy of prediction of 308-day milk yield. Correlation between actual and predicted milk yield increased with the advancement in lactation period. For the standard plan, correlation coefficients ranged from 0.79 to 1.00 at the first and 10th month of lactation. For the other plans range of correlation coefficients was 0.72 to 0.92, 0.70 to 0.91, 0.72 to 0.99, 0.70 to 0.99 for AM, PM, alternate AM-PM, PM-AM plans, respectively. Alternate AM-PM and PM-AM were generally better than either the AM or PM recording plans. Correlations were however, comparable for the AM and PM plans. Standard deviations of bias (difference between predicted and actual milk yield) were lowest (368 to 42 kg from the start to the end of lactation) for the standard plan, followed by the two plans where milk yield was recorded alternatively for the morning and evening milkings. The AM and PM plans had the highest standard deviations indicating that the estimated lactation yields had more variation than the other plans. Ranking of animals on the basis of their breeding values could also be done accurately using any of the five recording plans. Under field conditions however, feasibility was suggested to be considered for implementing any milk recording scheme as all the plans could predict milk yield and rank animals fairly accurately.

Improvement in prediction of lactation milk yield using last test day procedure has been suggested by Chaudhry (1998). Average daily milk yield included in the prediction equations not only improved the overall accuracy of prediction, bias was especially reduced for very poor or very high producing animals.

Test day models. To avoid the problem of extending test day yields to a 305-day record, abandoning the use of 305-day lactations yields in favor of test day yield has been suggested for genetic evaluation dairy sires and cows (Ptak & Schaeffer, 1992, 1993). The other advantages associated with this approach are better modeling of factors affecting yields and possibly better accuracy for genetic evaluations. Test day yields have same or slightly lower heritability than 305-day yield (Danell, 1982a; Meyer *et al.*, 1989) and by having four or more test day yields per lactation, a cow can have a more accurate genetic evaluation than from just one 305-day record (Ptak & Schaeffer, 1993). Multivariate BLUP based directly on test day records (Meyer *et al.*, 1989) and a repeatability model giving equal weight to each record, being computationally less demanding, have been suggested (Pander & Hill, 1993). Combining individual test-day yields into an overall lactation index after adjusting for age and stage of lactation and expressing as deviation from the sample day averages has been reported by Jones and Goddard (1990) for animal model evaluation.

The use of individual test-day information of yield traits is being debated for selecting dairy cattle and is likely to be adopted by the advanced production set ups. Advantages of such evaluations over 305-d 2X ME milk yield include: more accurate estimation of environmental effects from including the influence of particular days of recording; optimal use of information from all test days (especially for lactations with long intervals from calving to first test or between tests): improved accuracy of evaluation for component yields through contribution from information for milk yield; and greater stability of bull evaluations from accounting for genetic differences among daughters in the shape of lactation curve and maturity rate (Wiggans & Goddard, 1997). Adoption of such as procedure for genetic evaluation is likely to shift emphasis from 305-days lactation yield to individual test day information. Increased complexity of the statistical models and increased requirements for information storage are some of the disadvantages with this approach.

CONCLUSION

Lactation length accounts for most of the variation in milk yield of cows and buffaloes. Adjustment of this environmental factor is important for genetic evaluation of dairy animals. Early selection for partial lactation information can improve genetic gain. There are many adjustment procedures but use of last test day information using average daily milk yield of the known part of the lactation length is more accurate. Advantages of test day models over 305-day lactation yield are likely to change the need and modify the procedures of lactation length adjustment. Methods to develop such models for cattle and buffaloes under small holding situations need to be looked into for implementation in future.

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