Studies on the Development of Novel 305 day Adjustment Factors for Production Traits in Dairy Cattle

K. H. Cho, S. H. Na, J. H. Cho[1], J. H. Lee[2] and K. J. Lee[2,*]
National Livestock Research Institute, RDA, Korea

ABSTRACT : This study was conducted to develop a novel adjustment factors for 305 days using 138,103 lactation records and 1,770,764 daily records, which were based on environmental circumstances such as herd year, season, age at calving, dry period and lactating stages. The present study showed that the change of persistency of cows at the first parity from total lactacting characteristics was slowly processed, while it was rapidly changed in cows at the second parity stage. Particularly, there was an outstanding difference between the first and second parity cows. Milk yield and composition increased as the age at calving was increased. In addition, milk yield and composition were higher at the first parity on fall compared with others, and those were higher at the more than second parity on fall and winter compared with other parity stages and seasons. The cow of dry group was included into lactating records of more than second parity stage. The data indicated that optimal results arose from 45-70 days of dry period. Milk yield was decreased when dry period was longer or shorter than 45-70 days. The lactating days were divided into 17, 28 and 38 stages to compare the multiplicative correction factors. The factor was effective at 28 stages on the first parity. The total correlation coefficients were 0.93832, 0.95058 and 0.95076 at the present correction factor, 17 stage and 28 stage, respectively. At second parity, the factor was higher in dry group 1 and 3 at 17 stage, and it was higher in dry group 2 at 28 stage compared with others. Therefore, the present study showed that the percent squared bias (PSB), which was calculated from the novel correction factor, was better than previously used correction factors. Also, the present study indicated that the bias of the novel correction factor was improved, and this factor could be more accurate compared with others. ***(Asian-Aust. J. Anim. Sci. 2004. Vol 17, No. 12 : 1689-1694)***

Key Words : Novel 305 day Adjustment Factors, Multiplicative, Correlation Coefficients, Percent Squared Bias (PSB)

INTRODUCTION

The 305 day adjustment factors for production traits of dairy cattle can standardize the different milk yields due to different milking days of individual cows. These factors provide the opportunity of comparing milk producing abilities and the basis for evaluating the precise genetic abilities. If milking is in progress or incomplete record are used by adjusting these situations earlier, assumption on the milk producing ability is possible and by progeny test the generation interval can be reduced as well. For that reason, a variety of investigations and researches have been made for developing more precise adjustment factors on the production traits of dairy cattle. (Keown, 1972; Danell, 1982; Batra, 1985; Wilmink, 1987ab; Khan and Shook, 1996).

Lee et al. (1995) reported the first adjustment factors which are suitable for Korean dairy cattle. It provides a basis of standardization for different milk yields of dairy cattle and gives positive effects on cattle improvement and also profits to dairy farmers. The number of cows which produce over 20,000 kg of milk yield, are still increasing. In 2001 tested cattle farms had over 8000-kg milk yield and in 2002 305 day test results were as follows: 8,761 kg total milk yield, milk fat yield 330 kg, milk protein yield 278 kg, and solid not fat (SNF) yield 764 kg. In particular, the increasing tendency of milk yield indicated the enhancement of milk yielding abilities of dairy cattle herd in Korea (Dairy Cattle Improvement Center, N.A.C.F., 2003). High production efficiency in livestock production is an economically desirable that targets ultimately for genetic up gradation (Dhaka, 2002).

Cows' milk yield ability is dependent upon a variety of environmental elements such as the mixing skill of feed, quality enhancement, the development of feeding techniques, the change of climate due to the Greenhouse effect, and the parity shift from improved calving ability. In order to eliminate to eliminate these effects, new adjustment factors should be developed for predicting the precise 305 day production traits with intervals. This is a good way to prevent the ever-changing environmental elements, effectively. Taking the tested data ranging from 1999 to 2003 into consideration, this research illuminates the environmental elements of age, delivery seasons, lactation of dry periods, and to estimate the lactation curves. Moreover, the adjustment factors on the basis of division of lactation periods can be developed. By dividing test data according to the lactation periods, the adjustment factor can be attained; this research aimed at finding the relationship between existing and new adjustment factors on actual 305

* Corresponding Author: K. J. Lee. Tel: +82-2-450-3687, Fax: +82-2-455-5305, E-mail: kjlee@konkuk.ac.kr
[1] Dairy Cattle Improvement Center, N.A.C.F. Korea.
[2] Department of Dairy Science, College of Animal Husbandry, Kon-Kuk University, Hwayang-dong 1, Gwangjin-gu, Seoul, Korea.
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Table 1. Basic for various variables

Variables	OBS	Means	SD[1]	Min	Max
Parity	1,770,674	2.47	1.52	1.00	10.00
Tno[2]	1,770,674	5.19	2.73	1.00	11.00
Cumday[3]	1,770,674	154.11	86.07	1.00	310.00
Milk	1,770,674	27.62	7.77	2.60	50.20
Fat	1,770,674	1.04	0.30	0.06	1.92
Protein	1,770,674	0.87	0.23	0.12	1.56
SNF[4]	1,770,674	2.38	0.66	0.22	4.33

[1] Standard deviation, [2] A time of test day. [3] Cumulative milking day.
[4] Solids not fat. [5] Somatic cell scores.

day accumulated milk yield, and developing the best adjustment factors for 305 day milk yield under current situation of Korean dairy farming.

MATERIALS AND METHODS

Materials

This research deals with the tested data collected by Dairy Cattle Improvement Center, N.A.C.F. ranging 1999 January to 2003 January. Among the total 5,541,122, 3×SD was restrictively used for the records of milk yield and milk components; parity was limited to the tenth; accumulated milking days were determined within 310 days, and the respective records on lactations are composed of 1,770,764 test records over eight times and 138,103 records on milking two times a day and the basic data shown on Table 1. This study was carried out using the data from Dairy Cattle Improvement Center, National Agricultural Cooperation Federation.

Statistical analysis

In case of milk yield and milk components, the linear model is available to reveal the environmental effect. By executing the analysis of variance (ANOVA) which was suitable to the generalized linear model of SAS version 8.1, the least square means can be gained.

$Y_{ijk} = \mu + HY_i + SAL_j + e_{ijk}$ -----------------(I) First parity

$Y_{ijk} = \mu + HY_i + SADL_j + e_{ijk}$---------------(II) Second parity

Where, Y_{ijk} is the observation for milk yield and milk component on the ijkth cow.

μ is overall mean.

HY_i is the effect of herd-year, (I): (i=1, 2, ..., 12,310) (II): (i=1, 2, ..., 14,719).

SAL_j is the effect of the jth season of calving-age-stage of lactation of first parity (j=1, 2, ..., 224).

$SADL_j$ is the effect of the jth season of calving-age-dry-stage of lactation of second parity (j=1, 2, ..., 672).

e_{ijk} is the residual effect.

RESULTS AND DISCUSSOIN

Environmental effects show meaningful differences respectively in milk yield, milk components and somatic cell count. Considering calving seasons, the results of producing more milk yield and components for fall and winter group correspond to the cases in foreign countries (Tekerli, 2000).

To investigate the parity effect, all the parity data were analyzed; in particular difference between the first parity and others was outstanding, so different model methods were adapted between them. In the case of dry periods they were divided into four different groups-under 45 days, 45 to

Table 2. Least square means and standard errors for milk production traits and by age groups at first and second parity

Age	Milk		Fat		Protein		SNF[1]	
Group	LSM[2]	SE[3]	LSM	SE	LSM	SE	LSM	SE
1 (30≥)	25.561	0.035	0.951	0.001	0.804	0.001	2.212	0.003
1 (30<)	26.296	0.040	0.986	0.001	0.831	0.001	2.273	0.003
2 (72≥)	29.218	0.026	1.074	0.001	0.911	0.001	2.488	0.002
2 (72<)	29.156	0.029	1.061	0.001	0.896	0.001	2.449	0.002

[1] Solids not fat. [2] Least square means. [3] Standard error.

Table 3. Least square means and standard errors for milk production traits by season group at first and second parity

P[1]	S[2]	Milk		Fat		Protein		SNF[3]	
		LSM[4]	SE[5]	LSM	SE	LSM	SE	LSM	SE
1	1	25.877	0.038	0.961	0.001	0.815	0.001	2.229	0.003
	2	25.394	0.039	0.962	0.001	0.811	0.001	2.213	0.003
	3	26.457	0.038	0.993	0.001	0.832	0.001	2.301	0.003
	4	25.985	0.038	0.958	0.001	0.811	0.001	2.227	0.003
2	1	29.089	0.029	1.055	0.001	0.897	0.001	2.449	0.002
	2	28.472	0.029	1.055	0.001	0.893	0.001	2.423	0.002
	3	29.608	0.028	1.095	0.001	0.919	0.001	2.520	0.002
	4	29.579	0.028	1.066	0.001	0.904	0.001	2.480	0.002

[1] Parity, [2] Season group, [3] Solids not fat. [4] Least square means, [5] Standard error.
1: Mar.-May. 2: Jun.-Aug., 3: Sep.-Nov., 4: Dec.-Feb..

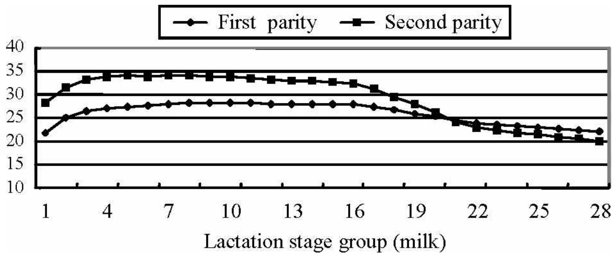

Figure 1. Trends for milk yields by lactation stage at first and second parity.

70 days, 71 to 90 days, and over 91 days. After operating multiple range tests on each of them, analysis of variance was taken. In sum, calving age and seasonal effect on calving are as following in Table 2 and 3.

Taking seasonal factors into consideration, Keown (1986) and Van Vleck (1987) tried to prove the seasonal effects with fixed effect model; Ko (1989) estimated milk yield according to month and parity by using regression in calving year and season. It shows the seasonal effects between parities. As Syrstad (1975) indicated that calving year and season had influence on milk yield, and fall and early winter was the optimal season for calving, and also the data from the first parity revealed milk yield and components of fall are recorded highest; this confirms that season has influence on milk yield. Also, in the second parity, calving seasons of fall and winter show the highest figures in milk yield and components.

Stages of lactation were divided into three periods: early, mid and late. According to the lactation methods, early lactation (1 to 90 days) shows the peak milk yield so that this lactation curve was divided more specifically into 28 stages as a whole. From Figure 1, as for stage of lactation there is a difference between first parity and second; as for milk yield there is a decreased inclination in stage 16; as for milk fat there is consistence in the first parity, however, in the second parity there is a decrease in stage 16. After the stage 21 lactation in the first parity earns more milk yield than in the second parity. This phenomenon indicates the stage of lactation is important to environmental elements regarding the difference of milk yield according to the stages of lactation. Thus this shows the same result that persistency of lactation in the first parity is higher than in the second parity but there is lower peak milk yield in the first parity (Keown, 1972; Kellogg, 1977; Schaeffer, 1977; Shanks, 1981).

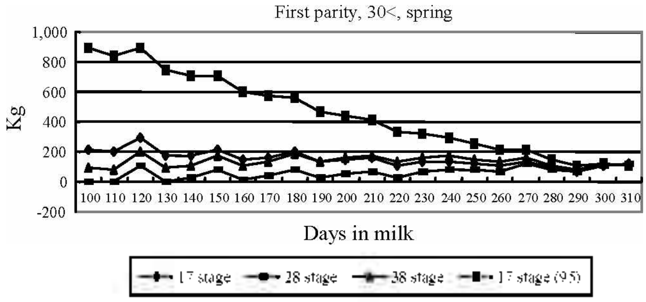

Figure 2. Comparison of residuals for the correction factors by lactation stages (30<).

Dry milk is the most important period as a kind of preparation period in that it means the period of storing nutrition factors for next lactation, not the end of one lactation period by stopping milking. Comparing the cows of no dry period with similar herdmates of having dry period, similar herdmate which has a dry period, it is reported that the former shows the decrease of milk yield (Remond, 1997). Also, if a cow has too short dry period and vice versa, milk yield was increased in Group 2 shown on Table 4. This research shows that the optimal dry period is between 45 and 70 days; whereas other approaches considered the optimal period 40 to 60 days (Coppock, 1974) and 51 to 60 days (Jagannatha, 1994). It is not advisable to have a short dry period in Group 1, a short period caused the least milk yield and milk elements; otherwise it showed increased somatic cell count. The longest dry period in Group 4 has the least milk yield. This result indicates that long dry period is related to the fact that shortened period of lactation means the decrease of milk yield so that it can affect reduction of income. In addition, the environmental elements of immunity have influence on increase and decrease of milk yield (Choi, 2003); thus it is proved that age and season of calving, and the stage of lactation will be the important elements. This research has tested the 45 to 90-day dry period in Group 2, and divided into 3 groups because we cannot approve the variance of Group 2 and 3.

In Figure 2, considering the adjustment figures of actual milk yield since mid lactation, the comparison of random

Table 4. Least square means and standard errors for milk production traits by dry period groups at second parity and above

Dry[1]	Milk		Fat		Protein		SNF[2]	
	LSM	SE	LSM	SE	LSM	SE	LSM	SE
1	27.650	0.029	1.016	0.001	0.867	0.001	2.350	0.002
2	30.022	0.027	1.094	0.001	0.928	0.001	2.540	0.002
3	29.800	0.030	1.088	0.001	0.918	0.001	2.515	0.002
4	29.276	0.030	1.072	0.001	0.900	0.001	2.467	0.002

[1] Dry group, [2] Solids not fat, [3] Somatic cell count.

1: <45, 2: 45≤dry<71, 3: 71≤dry<91, 4: 91≤dry.

Table 5. Correlation coefficients for corrected milk yields of the old and corrected milk yields by stages at first parity

Lactation periods (day)	Records	Old[1]	Novel[2] 17 stage	Novel[2] 28 stage	P value
Total (21-305)	20,299	0.93832	0.95058	0.95076	<0.0001
Early (21-90)	904	0.80308	0.81555	0.81755	<0.0001
Middle (91-240)	11,953	0.92825	0.93551	0.93551	<0.0001
Late (241-310)	7,468	0.99436	0.99557	0.99564	<0.0001

[1] Present correction factor, [2] The novel correction factor due to this study.

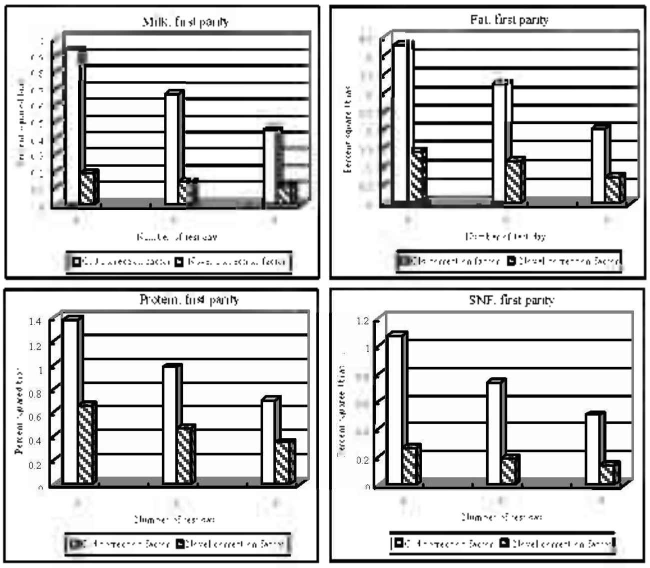

Figure 3. Comparison of old and novel correction factor for percent squared bias between estimated and true 305 day yields of production traits at first parity.

errors indicates rather similar results between stage 17 and stage 28, and less error than stage 38. The errors of the existing adjustment factors are more than the novel factors and the errors of stage 28 are the least after over 30 months. This research took the data shown in spring for the seasonal distinction makes no difference. Examining the curve shift of adjusted milk yield by stages of lactation the best adjustment appeared on stage 28.

305 day adjustment factors should be redeveloped periodically and require updating at short intervals. Adjustment factors for milk, fat, and protein yields by age and season of calving were reestimated (Keown, 1985). This study was using the multiplicative method.

The genetic trend from records with multiplicative adjustment was substantially greater than additive and optimal adjustments, especially during recent years. Age-season adjustment factors in the US have used a multiplicative rather than an additive method. Additive adjustments affect only means for age and season, but multiplicative adjustments also modify variance in proportion to the square of the adjustment factors (Khan, 1996).

Multiplicative factors were calculated as ;

$$\sum_{i=1}^{28} S_i(LSM_i) = Y_{305}$$

S_i is the lactation interval days of the ith lactation stage.

LSM_i is the least square mean of the ith lactation stage by age-season of calving.

Y_{305} is 305 d milk yield.

This method were reported reasonable to develop multiplicative factors because production level was increased and relationship between mean and variance exist (Lee, 1995).

Test by making use of correlation coefficient

To test the accuracy of adjustment factors, lactation records of actually over 305 days are examined. In general the lactation interval is different according to the lactation stages so we should divide the lactation periods. In proportion to the lactation periods, 28 stages and 38 stages have the similar lactation stage, so that correlation coefficients in stage 17 and 28 are compared. In the case of the first parity, total correlation is revealed to be 0.93832 with old adjustment factors, while novel factors showed 0.95058 and 0.95076 with 17 and 28 stages, respectively and thus the factors in stage 28 appears more accurate. Examining the stages of lactation, early to late lactations showed higher correlations than those of old correction factors (Table 5). However, in case of the second parity, the dry group 2 in 28 stages showed higher correlations, while group 1 and 3 in 17stages showed higher correlation. Investigating the periods of lactation, there is the same trend in the first parity but is more or less low correlation coefficients as a whole. That is the reason why individual cows are adapted after the second parity without adjustment between parities.

In the case of the first parity, from Table 6 the novel adjustment factors for milk yields and milk components showed higher values than those of the previous factors, when divided according to the lactation stages; the novel factors are proved to be more accurate. However, it seems somewhat complicated that the second parity includes dry milk groups. With or without the dry milk group, there is no distinct difference between lactation periods. This suggests more precise adjustment methods are needed.

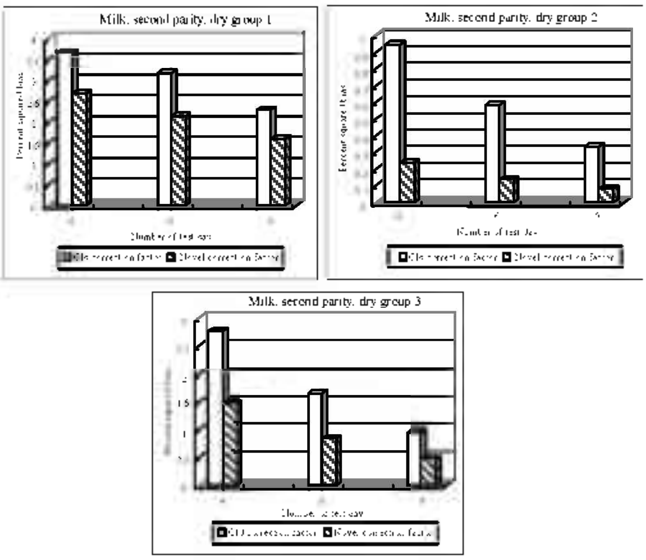

Figure 4. Comparison of old and novel correction factor for percent squared bias between estimated and true 305 day milk yields at second parity.

Test by making use of percent squared bias

$$PSB = \frac{\sum_{i=1}^{n}(E\hat{Y}_i - TY_i)^2}{\sum_{i=1}^{n} TY_i^2}$$

where, $E\hat{Y}_i$= estimated 305 day yield.
TY_i=actual 305 day testday yield.
i=the i^{th} test.
n=the total number of test.

This figure shows the difference between actual amount of milk and presumptive one. In other words, the more difference of PSB (percent squared bias) it has, the more it has the bias between currently used adjustment factors and newly improved ones. Owing to the realistic difficulties, this research has used test day milk yields, not everyday 305 day milk yield. That is, PSB puts test number instead of test milk yield and respective lactation periods.

In the case of first parity as shown in Figure 3, the increase of lactation, ie., test number and the decrease of PSB corresponds to the results of Archer (1994). There is a great deal of different bias in milk components; this suggests the optimacy of the novel adjustment factors. In the second parity, only the milk yield is presented and dry 2 Group, which has the least bias, shows the best adjustment according to Figure 4.

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CONCLUSION

For the past 10 years, the continual improvement of dairy cattle in Korea has brought the remarkable enhancement of production traits. In this respect, this research has investigated the environmental effects on age, calving season, lactation period and dry; besides, dividing test records according to the lactation stages, we can develop the novel adjustment factors. The stage 28 was the best adjusted stage of lactation regarding to the actual 305 day milk yield. Considering the correlations between existing adjustment factors and novel adjustment factors, and the PSB on the actual 305 day milk yield, novel multiplicative adjustment factors are the most suitable to the contemporary dairy cattle herd in Korea. With this research the newly-developed 305 day adjustment factors, acquired by use of the stages of lactation, are expected to help dairy management and increase dairy profits in that the factors can be used for enhancement of productivity by managing dairy cattle effectively. Besides, more precise genetic evaluation on the cows that are improved genetically can be expected and it can play an important role to develop progeny test programme; by selection for superior sires and elite cows on the basis of accurate evaluation on productive ability it may be available for the effectiveness and development of dairy cattle breeding. The information on the data of 305 day adjustment factors is presented on the website http://kkucc.konkuk.ac.kr/~kjlee.

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