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COW INDEXING IN DAIRY HERDS[1]

E. COLLINS-LUSWETI[2]

Institute of Animal Genetics, Edinburgh University,
Edinburgh, Great Britain

Summary. Using the official Milk Marketing Board 305-day milk and butter fat yield records for the East Scotland School of Agriculture — Langhill Farm, the breeding values of 74 Langhillbred Friesian cows were estimated as the cow predictive index combining information from both the dam and sire. A correlation of 0.44, on average, was found between the cow index and the phenotypic performance of the cow expressed as deviation from the contemporary mean.

The results indicate that the farmer using the cow index could objectively decide which cows to cull for low production, which cows to breed to obtain heifer replacements and which cows to mate as bull mothers provided the index is calculated from the performance data from the cow's own record, the dam record and the sire ICC rating. The results, further, indicate that use of more than one record on the cow and the dam adds very little to the accuracy of the index.

A cow index is widely used in dairy breeding programmes as an aid in the selection of bull dams and within herd selection of dairy cows. The objective of this study was to evaluate the relationship between cow indices calculated from pedigree data i.e. predictive index, and the actual phenotypic performance records with the view of determining whether a prodictive index is useful (as an alternative to an empirical assessment) and whether information from additional records from sire progeny tests and from dams improves the accuracy of the index.

DATA AND METHODS

The data used in this study were the official Milk Marketing Board (MMB) 305-day production records of the Edinburgh University dairy herd at Langhill farm for the period between 1969 to 1977. The herd consisted of 190 pedigree Friesian cows and heifers of which 74 fulfilled the minimum condition for indexing i.e. they had at least one completed lactation record and in addition, their pedigree

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[1] Received for publication: March, 1983

[2] Dr. Present address: Dept. of Animal Science, University of Maiduguri, P.M.B. 1069, Maiduguri, Nigeria.

records were available at the farm. The sire's Improved Contemporary Comparison (ICC) and the actual number of daughters used in calculating the index were obtained from official lists of sire proofs (MMB 1978). Assessment of milking performance.

For the assessment of the breeding value of the cow, the following sources of information were used: 1. The cow's own 305-day milk-yield records. 2. The records of the dam. 3. The sire's ICC.

For each cow's record, the average of her contemporaries and the cow's deviation from the contemporary average were calculated. For the cows with two or three lactations, their respective second and third lactation deviations from their contemporaries were also calculated. These calculations were also repeated for the dam's records.

For a contemporary comparison, cows of the same parity, calving between February and July each year were grouped together and compared to each other as contemporaries and those of the same parity, calving between August and January formed another group of contemporaries. It was assumed that this procedure removed most of the year and season effects. In the Langhill data, this method gave a reasonable number (on average 15) of contemporaries within year-seasons and hence it was quite a reliable comparison.

For each cow and dam record, an adjustment was made for a varying number of contemporaries by multiplying the cow or dam deviations, from their respective contemporary averages by a weighting factor $w=N/(N+1)$, where N denotes the number of contemporary records. From this the mean performance of an individual relative to its respective herd-mates was estimated as:

$$\bar{P}=w_1(y_1-\bar{Y}_1)+w_2(y_2-\bar{Y}_2)+\ldots w_n(y_n-\bar{Y}_n)\,w,$$

where $y_1 \ldots y_n$ are the 1st...nth records of the cow in question and $\bar{Y}_1 \ldots \bar{Y}_n$ the corresponding mean performance of the contemporaries.

P values were computed in this way for the cow herself and her dam. For the paternal 1/2-sisters the sire's ICC rating was used.

COMPUTATION OF THE INDEX

Having collected the information, it was combined into an index to give an estimation of the breeding value of the cow. INDEX (I)$=b_1\bar{P}_c+b_2\bar{P}_d+b_3\bar{P}_{\text{PHS}}$.

The b coefficients were derived by a routine procedure described by Henderson (1964) which requires the solution of 3 linear equations:

	cow	dam	PHS	
cow	$d_{11}b_1+\frac{1}{2}h^2b_2+1h^2b_3=h^2$			... (1)
dam	$\frac{1}{2}h^2b_1+d_{22}b_2+0b_3=\frac{1}{2}h^2$			... (2)
PHS	$1h^2b_1+0b_2+d_{33}b_3=1h^2$			... (3)

If some sources of information were lacking the corresponding equations were ignored. The diagonal elements ($d_{11}...d_{33}$) were obtained as follows:

$$d_{ii}=\frac{\frac{1+(n_i-1)r}{n_i}+(P_i-1)a_{P_iP_i}h^2}{P_i},$$

where h^2 — heritability (assumed to be 0.25 for milk yield), r — repeatability (assumed to be 0.40 for milk yield), n_i — the number of records, P_i — the number of animals in the group (e.g. number of paternal 1/2-sisters), $a_{P_iP_i}$ — the additive component of relationship within the group (e.g. 1/4 in the case of 1/2-sisters).

THE ACCURACY OF THE INDEX

This is a correlation between the index value and true breeding value of the cow and is calculated from the formula:

$$r_{IG}=(b_1+\tfrac{1}{2}b_2+\tfrac{1}{4}b_3).$$

Using the above methods, 3 performance records: P_1, P_2 and P_3 were calculated for each cow. P_1 was the cow's deviation from its contemporary mean in the 1st lactation; P_2 was the average performance of the cow in its 1st and 2nd lactations expressed as a deviation from its contemporary mean and P_3 was the average performance of the cow in its first three lactations also expressed as a deviation from the contemporary mean.

Three "Predictive Indices", were calculated for each cow: index I_{SD1} was computed from the sire ICC and one record on the dam; index I_{SD2} was calculated from the sire ICC and two records on the dam and index I_{SD3} was computed from the sire ICC and three records on the dam.

To assess the relationship between the individual cow performance and her predictive indices, the correlations and regressions between these two criteria were calculated according to Snedecor and Cochran (1967) method.

RESULTS

On average the accuracy of the indices was found to be $r_{IG}=0.75$. The correlations and regressions between the individual cow performance and her predictive indices are shown in tables 1 to 4.

Table 1. Correlation between individual cow performance (milk) and their predictive indices

	I_{SD^1}	I_{SD^2}	I_{SD^3}
P_1	0.59±0.10*	0.44±0.10*	0.44±0.11*
P_2	0.47±0.12*	0.44±0.11*	0.45±0.14*
P_3	0.16±0.19	0.16±0.10	0.18±0.22

* Significantly different from zeroa $tP<0.05$

Table 2. Correlation between individual cow performance (fat) and their predictive indices

	I_{SD_1}	I_{SD_2}	I_{SD_3}
P_1	0.32±0.11*	0.27±0.11	0.33±0.12
P_2	0.31±0.14*	0.23±0.14	0.33±0.15
P_3	0.10±0.19	0.05±0.19	0.22±0.21

* Significantly different from zero at $P<0.05$
On average the correlation between milk indices and fat indices was found to be 0.81

Table 3. Regression of individual cow performance (milk) on their predictive indices

Y-variate Constant	P_1	P_2	P_3
I_{SD_1}	1.44±0.41*	1.48±0.42*	0.76±0.90
I_{SD_2}	1.96±1.01	0.06±1.15	0.26±2.50
I_{SD_3}	0.65±0.94	0.34±1.03	0.69±1.95

* Significantly different from zero at $P<0.05$

Table 4. Regression of individual cow performance (fat yield) on their predictive indices

Y-variate Constant	P_1	P_2	P_3
I_{SD_1}	1.14±0.39*	0.82±0.38*	0.55±1.06
I_{SD_2}	0.39±0.91	1.21±1.17	1.13±2.36
I_{SD_3}	0.91±0.79	1.30±0.87	2.04±1.68

* Significantly different from zero at $P<0.05$

DISCUSSION

Due to the fact that selection for milk and butter fat yields is still the most widely used criterion, this study was mainly concerned with cow indexing on the basis of milk and butter fat yields. A cow index, based on the estimated breeding values of the cows, provides the farmer with a realistic and reasonably accurate indicator of the best and worst cow in the herd. It was shown in the presentation of the results that cows will differ in ranking when ranked on the predictive index compared with the individuals own performance i.e. the correlation between the individual performance and the predictive (Dam+Sire) index was found to be 0.44, on average. From this study, therefore, it can be said that an index will allow the farmer to select the best and to cull the low producers in an objective way provided the index is calculated from the performance data of the cows own milk yield, the dam records and the sire ICC rating.

Other than culling, the index has other uses such as in selecting heifers to replace culled cows and selecting cows to breed bulls for artificial insemination service.

The cow's own records represent the only direct measure of her genetic value. However, these can at best, only provide an inaccurate estimate of her genotype for milk yield. Records subsequent to the first lactation increase the accuracy of the assessment, but at progressively diminishing rate (Freeman 1970, Schmidt and Van Vleck 1974). This agrees with the results in this study which indicate that the correlation between the cow's average performance in the first two and first three lactations and her predictive breeding index is lower than the correlation between her first lactation performance and her predictive index. It appears that in calculating the predictive index, an increase in the number of records on the cow and on the dam adds very little, the use of first lactation alone appears adequate. Barker and Robertson (1966), Syrstand (1971) have quoted larger heritabilities for the first lactation record than for subsequent records. In the light of their findings and the facts that the variance in all lactations may not be normally distributed and the genetic correlations between lactations are not unity, it can be concluded, from this study, that only the first lactation record of the cow and her dam should be used in the cow index, as is the case for the calculation of the sire proof.

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INDEKS SELEKCYJNY DLA BYDŁA MLECZNEGO

Streszczenie

Posługując się danymi otrzymanymi z „Milk Marketing Board" dla 305 dni wydajności mlecznej i zawartości tłuszczu w mleku 74 krów fryzyjskich z gospodarstwa Langhill należącego do East Scotland School (Wielka Brytania) opracowano indeks dla przewidywanej pro-

dukcyjności krów. Stwierdzono korelację wynoszącą średnio 0,44 między indeksem krowy i jej fenotypową wartością wyrażoną jako odchylenie od aktualnej średniej.

Wyniki wskazują, że hodowca wykorzystując indeks selekcyjny krowy mógłby obiektywnie decydować o eliminacji, wyborze do dalszej hodowli, lub przeznaczeniu krów na matki buhajów. Należy brać pod uwagę indeks obliczony z danych dotyczących produkcji własnych krów i buhajów. Wyniki wskazują także, że użycie więcej niż jednego zestawu danych dotyczącego krów i ich matek łącznie, wpływa w niewielkim stopniu na dokładność indeksu selekcyjnego.

СЕЛЕКЦИОННЫЙ ИНДЕКС ДЛЯ МОЛОЧНОГО СКОТА

Резюме

Используя данные, полученные от „Milk Marketing Board" для 305 дней удоя молока и содержания жира в молоке 74 коров фризской породы фермы Langhill, принадлежащей East Scotland School (Великобритания), был вычислен индекс для ожидаемой продуктивности коров. Обнаружена корреляция, составляющая в среднем 0,44 между индексом коровы и ее фенотипической ценностью, выраженной как отклонение от актуальной средней.

Результаты показывают, что использование селекционного индекса коровы при разведении может помочь в объективном решении о устранении, выборе для дальнейшего разведения или об оставлении коров на матки быков. Следует иметь ввиду индекс, вычисленный на основании данных касающихся собственных коров и быков. Полученные результаты также показывают, что использование более чем одного состава данных, касающихся коров и их маток вместе взятых, в небольшой степени влияет на точность селекционного индекса.