when the copper content of water approaches 0·1 p.p.m. the water is aggressive to aluminium. The small constant for copper in the equation is explained by the fact that the copper content of most of the waters tested was less than 0·03 p.p.m. It will be noted that bicarbonate is not included in the equation. It was found that the inclusion of this constituent did not decrease the standard error of the equation.

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Factors affecting Persistency of Lactation in Cattle

THE lactation curve in cattle has been represented by the function

$$y_n = An^b \exp(-cn) \quad (1)$$

where y_n is the average daily yield in the nth week and A, b and c are constants. I have previously[1] suggested a measure of persistency (the extent to which peak yield is maintained) given by

$$S = -(b+1)\ln(c) + \ln\Gamma(b+1) \quad (2)$$

which was related to expected total yield (Y) by $Y = Ae^S$.

This communication describes a further investigation based on a sample of 859 Friesian lactations recorded by the Milk Marketing Board of England and Wales during 1964–65. Parities 1 to 9 were represented and some animals had calved in each calendar month. A mixed model was assumed. Calving month and parity were considered fixed, but sires and herds were assumed to be random selections of all possible sires and herds. Analysis of variance (see ref. 2) led to the values in Table 1.

Table 1. ANALYSIS OF VARIANCE OF FACTORS AFFECTING PERSISTENCY

Source of variation	d.f.	Mean square
Month of calving	11	2·0000*
Parity	3	1·000*
Month × parity	33	0·1515
Bulls within month and parity	252	0·2607*
Herds within bulls	180	0·0930
Residual	379	0·0832

* $P < 0·001$.

As expected, persistency varied considerably with calving month and parity, and there were very highly significant differences between sire progeny groups. The monthly means are given in Table 2 together with the week of peak yield.

Table 2. MONTHLY VARIATION IN PERSISTENCY WITH WEEK OF PEAK YIELD

Month	S	Peak week	Month	S	Peak week
January	3·69	5·8	July	3·29	2·3
February	3·67	6·1	August	3·29	1·0
March	3·77	7·3	September	3·36	1·2
April	3·70	6·5	October	3·54	3·3
May	3·52	5·2	November	3·58	4·7
June	3·35	3·4	December	3·67	6·7

The tendency for the lactation starting in March to show an extended peak due to the stimulus of May grazing 6 to 8 weeks later is clearly shown. At the other extreme, the lactation starting in August rapidly falls away as the year closes. The means for different parities are given in Table 3, and the corresponding curves are plotted in Fig. 1.

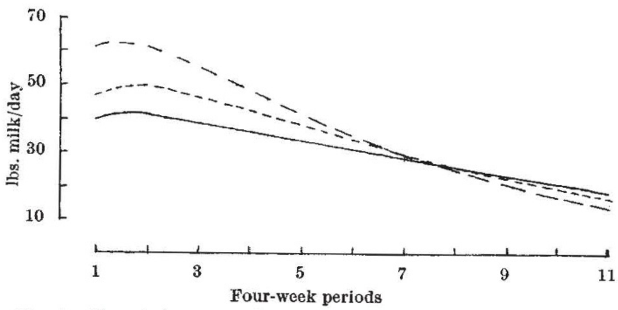

Fig. 1. Expected average daily yields during first three lactations, calculated from the function $y_n = An^b \exp(-cn)$. Note the decline in persistency with age. (Divisions along the axis are at period mid-points. ——, First lactation; - - -, second lactation; — — —, third lactation.)

Although the variation among bull progeny groups was large, the weighted mean number of records per bull was only 3·8 and was highly variable, so that the mean square is probably still biased. Nevertheless, using progeny groups of ten or more records, a reasonable estimate of the variance component could be obtained, which agreed closely with the data reported earlier[1].

A heritability estimate calculated from $4\sigma^2_s/(\sigma^2_s + \sigma^2_e)$, where σ^2_s is the component due to sire progeny groups and σ^2_e is the residual (error) variation, was $0·079 \pm 0·11$—a low figure in agreement with other opinions[3].

Persistency was negatively correlated with initial daily yield (−0·859) but positively correlated with total yield ignoring A (+0·311) and also with A held constant (+0·998). An approximation to the measure may be obtained from the definition of S, which leads to $S = \ln(Y) - \ln(A)$.

Table 3. EFFECT OF AGE OF COW ON PERSISTENCY TOGETHER WITH THE WEEK OF PEAK YIELD

Parity	S	Peak week
1	3·62	5·0
2	3·52	5·3
3	3·46	4·0
4 and over	3·55	4·8
Mean	3·53	5·0

Because Y is the expected total yield obtained by integrating equation (1) over its entire range, a good working estimate of S is obtained by integrating (1) over a finite range—say 44 weeks—on the assumption that what remains is equally trivial over all lactations and may be ignored. Y can therefore be set equal to the observed 305-day yield with very little loss of accuracy. A further approximation may be obtained from equation (1), which gives $A = y_1 e^c$. Because c is small (of the order $0·03 \pm 0·02$), e^c is unlikely to fall outside the range 1·01 to 1·05 so that $A \sim 1·03\, y_1$, where y_1 is the total yield in the first week of lactation.

Hence $S \sim \ln(Y) - \ln(y_1) - 0·03$, and it is unnecessary to retain full week by week records.

Persistency can be converted easily into gallons for, with A constant, $\exp(S_1 - S_2)$ is the proportion of total yield gained solely by a change in persistency. Referring to Table 3, the change from first ($S = 3·62$) to second lactation ($S = 3·52$) results in a reduction in yield of $e^{0·1}$ or 10·5 per cent, and so the observed increase from first to second lactation is the result of an increase in scale which more than compensates. Moreover, the component of variance due to sire progeny groups was 0·001767, and so the 95 per cent range due to this classification was 0·16 or 17·4 per cent of the 305 day lactation.

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