CHARACTERISING LACTATION CURVES IN HEIFERS OF DIFFERENT BREEDS FIRST CALVED IN MODERATE OR LOW CONDITION

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SUMMARY

Milk yields were measured every 6 weeks from 21220 days after calving in either moderate or low conditioned groups of Angus, Angus x Friesian or Simford first-calf heifers for 3 successive years. Day of peak yield, peak yield and total 220 day yield were calculated by fitting 3 published equations to data on each of the breed x year x calving condition combinations. All equations ranked breed and calving condition combinations similarly for 220 day milk yield, but peak yield and day of peak yield were more variable. The Jenkins equation consistently accounted for more variation in milk yield data (58%) compared with the Wood and Wood-weighted milk curves. Calf weight at 200 days and estimated 220 day milk yield (Jenkins) were highly correlated ($r = 0.59$, $P < 0.001$).
Keywords: lactation curves, first-calf beef heifers.

INTRODUCTION

Milk production of beef cattle is economically important because of its direct influence on calf weaning weights, efficiency and costs of production and maintenance (Montano-Bermudez and Nielsen 1990). Data on the milk yield of beef cattle under southern Australian grazing conditions are relatively few (Morgan 1991). Overseas studies have either provided a "snapshot" view for relative milk yields of cows of various breeds or nutritional treatments (Dawson *et al.* 1960) or have used lactation curve equations, similar to those for dairy cattle (Hohenboken *et al.* 1992). Few studies have reported the milk yield of first-calving beef heifers though weaning weights of their progeny are often 10-15% less than those of mature cattle.

This study evaluates how well 3 published equations fit lactation curves to periodic measurement of milk yield in first-calving beef heifers and examines the influence of breed and the condition at calving. The correlation of milk production ranking with calf growth was also determined.

MATERIALS AND METHODS

Animals, husbandry, pasture available and supplementary feeding

This work forms part of a larger experiment conducted at Vasse Research Station, near Busselton, Western Australia, between 1986 and 1988. The annual rainfall averages 750 mm (range 550-950 mm) with an 8 month growing season for annual pastures (April-November). Angus, Angus x Friesian F2 and Simford F2 heifers were allocated on the basis of liveweight and managed at pasture during spring (about the second trimester of pregnancy) so that there were 2 liveweight/condition groups (moderate and low) within each breed prior to calving. Over all years the weight and condition score (CS, O-5 scale) at first calving for moderate-conditioned Angus, Angus x Friesian or Simford heifers was 401 kg and 2.6, 439 kg and 2.2 and 472 kg and 2.4, respectively. Heifers in low condition were about 40 kg and 0.7 CS units less at calving. Cow and calf groups were rotated around paddocks at a stocking rate of 1 cow-calf unit/1.1 ha. Animals were weighed, condition scored and pasture on offer was assessed by a visual technique calibrated by 0.25 m^2 quadrat cuts (Sawyer *et al.* 1993), every 3 weeks throughout the experiment. Most heifers calved in March before the onset of significant seasonal rainfall (April). Pasture on offer ranged from 850-1500 kg DM/ha during the months of March-May, increased to 1100-1500 kg DM/ha for the next 3 months, then was consistently above 2000 kg DM/ha during the spring flush in 1986 and 1988. In 1987 pasture on offer was always 30-80% above that in the other 2 years, particularly after the break of season. Lactating first calvers were fed high quality silage at 6.0-10.5 (MarchApril), 5.0-8.0 (May), 3.0-7.0 (June) and 0-3.0 kg DM/hd.day (July). The quality of the silage (63-70% DM digestibility and 17.5% crude protein) ensured most animals only sustained minor weight loss during early lactation (range O-O.4 kg/day).

Milk assessment

Each year 7-10 animals of each breed and from each calving condition group were selected at random 21-35 days after calving for milk assessment, and 5 further measurements were taken, using these animals, every 35-42 days until calves were 180-220 days old. Milk production was measured by a weigh-suckle-weigh technique (Dawson *et al.* 1960). First-calvers were separated from their calves in the late morning before assessment. Calves suckled their dams at 1700 hours, were separated overnight, weighed and allowed to suckle their dams at 0600 hours; weighed again and milk weights converted to 24 hour production.

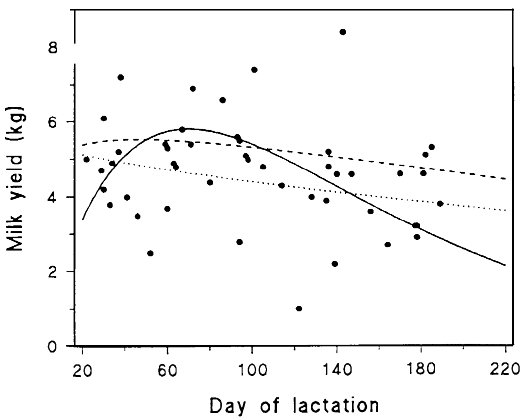
Lactation curves and analysis

The Wood (Wood 1967), Wood-weighted (Rowlands *et al.* 1982) and the Jenkins (Jenkins and Ferrell 1984) equations were fitted to the milk production data for each breed by condition group in each year. Each model also included a term for individual cow variation. Analysis of variance was used to examine the effects of breed, condition at calving, year and their 2-way interactions on the Jenkins' estimates of peak yield, day of peak yield and total 220 day yield. The year effect was significant, therefore data was not combined across years. The correlation between the Jenkins' estimate of total 220 day yield for each dam and the growth rate of their calf was also determined.

RESULTS

Lactation curves are presented for Simford heifers calved in moderate condition in 1986 as representative of all curves generated (Figure 1). The shapes of the Wood and Wood-weighted curves differed markedly according to the variability of milk yield measurements for the breed x calving condition x year combinations, whereas the Jenkins equation was a more consistent shape as the curve is forced through the origin (Figure 1). The Jenkins equation fitted the milk yield data more consistently than either of the 2 other equations tested. It accounted for an average of 57.5% of variance (range 31-80%) and the significance of the linear regression (log form of the equation) in all cases was $P < 0.001$. In contrast the Wood and Wood-weighted equations accounted for less than 27% of variance in milk yield data and significant linear regressions were only derived for half the breed x calving condition x year combinations.

Descriptive statistics characterising lactation curves for all first-calvers in 1986 are presented in Table 1. The Jenkins equation repeatedly produced a peak in lactation at about day 70 in 1986 whereas peak day of lactation varied more widely for the Wood and Wood-weighted equations. In subsequent years peak day of lactation was later (90-200 days). Peak yield and estimated total 220 day milk yield were generally greater in all combinations analysed if the Wood-weighted equation was used (Table 1). Across all breeds and calving condition groups the Jenkins equation estimated milk yield to 220 days ranging from 648 kg (Angus 1986) to 1496 kg (Angus x Friesian 1987, Table 2). Within any year all equations described a similar ranking in total 220 day production across breed x calving condition cells with Angus first-calvers producing the least milk and Angus x Friesians the most.



Variance accounted for:
Jenkins 77%
Wood 17%
Wood-weighted 22%

Figure 1 Lactation curves defined by the Jenkins (continuous line), Wood (dotted line) and Wood-weighted (broken line) equations for milk yield data (closed circles) from 60 Simford heifers first-calved in 1986. The logarithmic form of the Jenkins equation is $\log Y(n)/n = \log^1/a_3 - k_3 n$; the Wood is $\log Y(n) = \log a_1 + b_1 \log n - c_1 n$; and the Wood-weighted is similar to the Wood but with each $\log Y(n)$ weighted by $[Y(n)^2]$; where Yn is the daily milk production, n is day of lactation and a_1, b_1, c_1, a_3 and k_3 are estimated from the data.

With the Jenkins curve, breed ($P < 0.001$) and year ($P < 0.001$) significantly influenced total 220 *day* milk yield, the day and level of peak milk yield (Table 2). Condition at calving significantly affected only the total milk yield ($P < 0.05$). The only significant interactions were for both breed ($P < 0.001$, shown in Table 2) and condition at calving with year ($P < 0.04$) on total yield. In 1986 and 1988 heifers calved in low condition produced 9% and 28% less milk respectively, than those calved in moderate condition. In 1987, when feed on offer was 30-80% more, this difference was not apparent. The correlation between weight of the calf at 200 days and total milk yield (220 days) was significant ($r = 0.59$, $P < 0.001$) and resulted in a similar ranking of cow productivity based on either calf 200 day weight or 220 day milk production as estimated by the Jenkins equation.

Table 1. Milk production variables estimated from lactation curves for all heifers calved in 1986

Breed	Equation	Peak day	s.e.	Peak yield (kg)	s.e.	220 day yield (kg)	log 220 day yield	s.e. (log)
Angus	Wood	65	7.6	4.0	0.29	658.5	6.49	0.055
	Wood-weighted	55	4.8	4.8	0.33	854.1	6.76	0.052
	Jenkins	72	2.4	4.3	0.37	645.5	6.47	0.057
Angus x Friesian	Wood	59	15.0	5.2	0.68	982.4	6.89	0.055
	Wood-weighted	68	4.6	5 7	0 33	1152.8	7.06	0.053
	Jenkins	70	2.4	5.9	0.37	897.8	6.80	0.057
Simford	Wood	1	-	4.4	0.58	906.9	6.81	0.053
	Wood-weighted	8	7.9	6.2	0.70	1002.2	6.91	0.051
	Jenkins	70	2.3	5.5	0.36	843.5	6.74	0.055

Table 2. Effects of breed and year on milk production estimated using the Jenkins equation

Breed	Year	Peak day	Peak yield (kg)	220 day yield (kg)
Angus	1986	72	4.3	648
	1987	150	7.7	1282
	1988	78	5.5	859
Angus x Friesian	1986	70	5.9	902
	1987	213	9.5	1496
	1988	100	8.1	1373
Simford	1986	70	5.5	844
	1987	130	7.2	1233
	1988	94	4.9	826
min-max s.e.		2.3 - 2.9	0.36 - 0.45	1.05 -1.07

DISCUSSION

Under the conditions of this study we found that published equations, several of which were originally used on dairy cattle (Wood 1967; Rowlands *et al.* 1982), could characterise the lactation curves of first-calving beef heifers. This enables maximum use of research data which may be included in models of beef production under grazing and supplementary feeding situations, and in breeding and production efficiency studies. The Jenkins equation consistently fitted the milk yield data better than the Wood or Wood-weighted equations. This result contrasts with that of Hohenboken *et al.* (1992) who used autumn calving Angus and Angus x 1/4Holstein beef cows. They found that all equations ranked cows similarly for milk production and the Wood-weighted equation characterised the lactation curves best, but no details of nutritional management were supplied.

The shape of the curves we fitted was not "typical" of milk production curves most commonly used in the dairy industry. The Jenkins equation showed peak yields at least 10 weeks into lactation, considerably later than peak dairy cow yields, and the general shape of the curve was flatter. Suckling young calves may not be able to consume all the milk produced in the period studied, and this could account for the better fit of the Jenkins curve to our data. Other work using injections of oxytocin and either machine or hand milking gave higher estimates of production in early-mid lactation cattle, similar to the Wood equations (Morgan 1991, Hohenboken *et al.* 1992). The 220 day total yield derived by integration of the curve was highly correlated with calf 200 day weight, confirming the suitability of the Jenkins equation to characterise lactation curves in beef cattle run in a mediterranean environment.

A feature of this work was the considerable variability encountered both among animals and between breeds and years. Though the same relative rankings for the various breed x calving condition x year combinations were maintained no matter what lactation curve equation was used, there was almost a 3-fold difference between highest and lowest 220 day milk yield. Under these conditions average estimates of peak and total milk yield using the Jenkins equation were always associated with less variation than with either of the Wood equations. There was a marked effect of year, reflecting excellent annual pasture growth in 1987 which increased total milk yield by about 50% compared with other years. This was despite supplementary feeding with good quality silage which kept early lactation liveweight loss to a minimum in all years. Pasture quantity in 1987 over-rode any effect on subsequent milk yield from reduced body reserves in heifers of all breeds calved in low condition (CS 1.5-1.7). This finding emphasises how responsive this class of beef breeder can be to good nutrition and confirms their requirement for preferential treatment, especially quality nutrition, for optimum production.

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