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CURVE ANALYSIS AND PREDICTION OF LACTATION YIELD VARIABLES AMONG BROWN SWISS, WHITE FULANI AND BROWN SWISS X N'DAMA CROSSES

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ABSTRACT

879 total lactation records consisting of 5481 weekly milk production records of three dairy breeds namely Brown Swiss, White Fulani and Brown Swiss x N'Dama, were fitted to three lactation curves prediction functions. The resultant lactation curves and production variables were analysed. Incomplete gamma followed by exponential function was able to estimate better persistency values of 4.09-4.62 and 2.999-3.479 respectively for the three breeds. Incomplete gamma function was best in predicting lactation curve parameters for the three breeds considered in this study. The lactation curves showed that all the functions at one time or the other underestimated the curve. However, incomplete gamma had better predictive strength in tracking the actual curve of the milk yield.

Keywords: Lactation, prediction function, curves.

INTRODUCTION

In dairy cattle production system, it is desirable that the milk production by the cow is acceptable, that is enough to allow for a longer period of production without affecting the milk composition. However, researchers have characterised dairy milk production using a wide range of mathematical model that regress the average yield per unit time (Rook *et al.*, 1993). Although the mathematical formulations of these equations differ, they produce similar graphs reflecting generally some desirable biological characteristics. Lactation curves analysis is helpful in identifying the detailed performance of the animal such as level of feeding, management problems in the herd, peak yield, persistency and lactation yield. Peak yield and persistency are more important as management tools for monitoring milk production performance in the herd (Kumar *et al.*, 1993). The objective of this study is to comparatively analyse the resultant lactation curve generated using three prediction functions on lactation yield of Brown Swiss, White Fulani and Brown Swiss x N'Dama crosses.

MATERIALS AND MATHODS

The data used in this study were weekly milk production records maintained at the University of Ibadan Teaching and Research farm. From the records, 879 complete and accurate lactation records consisting of 270,501 and 108 normal lactation for Brown Swiss, White Fulani and Brown Swiss x N'Dama cows respectively were analysed. Lactation records characterised by abortion, stillbirth, death and incomplete lactation due to sickness were discarded. The cows were machine milked at 0500h and 1430h daily. The amount of milk recorded per animal per week was used to generate milk yield per cow per month of lactation. The data extracted from the records covered a period of 10 years (1976-1985 inclusive).

Three functions, namely, incomplete gamma, inverse polynomial and exponential function were fitted to the respective data set to estimate the prediction function parameters and generate the lactation curve for the three breeds of cow- Brown Swiss, White Fulani and Brown Swiss x N'Dama. These functions were chosen because they have shown to be the most successful in fitting lactation data (Yadav, 1977; Kumar *et al.*, 1993; Tozer and Huffaker, 1999). Cumulative monthly milk yield for Brown Swiss, White Fulani and Brown Swiss x N'Dama cows were used in estimating the parameters contained in the following functions below and generating the curve using a non linear regression procedure of SAS (1999) analytical package.

1. Incomplete gamma function by Wood (1967)

   This equation has been intensively used in estimating lactation curves in the temperate countries. The function as proposed by Wood (1967) has the following formulation:

   $$Y_t = at^b e^{-ct}$$

2. Inverse polynomial function by Nelder (1966)

   This is another function that has een used for dairy cattle curve generation and is of the form:

   $$Y_t = t(a + bt + ct^2)^{-1}$$

3. Exponential function by Brody *et al.* (1923)

   The general function as propose by Broody et al. is of the form:

   $$Y_t = ae^{-ct}$$

Where: Y_t = milk production in time t
a = initial milk yield after calving
b = measure of ascending rate to peak
c = rate of change during the declineing phase
e = exponential sign

RESULTS AND DISCUSSION

As shown in Table 1, the three functions converged statistically and the parameter estimates were significant at $P<0.05$ with respect to Brown Swiss, White Fulani and Brown Swiss x N'Dama crosses. This shows that the three prediction functions are well able to predict the lactation curve for the three breeds considered. The lower residual means square obtained for all the function with respect to Brown Swiss x N'Dama crosses might not be unconnected to the size of the data. Residual means square which detects the suitability of the functions to predict the curve and also the short-term variations in the over time evolution of milk production. Thus the higher residual means square observed in the Brown Swiss reveals a lot of variation in the overall milk production. This may be due to the climate and management regime adopted for the imported breeds. Incomplete gamma in Brown Swiss had the highest value of 102.88 among the three breeds, inverse polynomial in White Fulani had the highest residual mean square (61.5) while exponential function had the highest residual means square of 266.4 in Brown Swiss. The initial milk yield (a) estimate of 30.3 obtained by Tozer and Huffaker (1999) was higher than the result in this study while the rate of milk yield increase (b) estimates was lower than the estimates in this study. The estimated a, b and c values obtained in White Fulani were greater than what Hohenboken *et al*. (1992) reported for beef cows. The Wood function performed best for White Fulani. The parameter estimates obtained for Brown Swiss x N'Dama crosses showed that Wood function performed better compared to the other two functions. However a contrary report by Yadav *et al.* (1977) showed that inverse polynomial was best in predicting curve parameters in crosses between Hariana and Friesian cattle.

Table 1: Lactation curve parameter estimates of three functions on Brown Swiss, White Fulani and Brown Swiss x N'Dama crossbred cows

Model	**Parameters**	**Estimates**		
		BS	**WF**	**BSND**
Incomplete gamma function	a	28.837a	29.497a	24.66b
	b	0.291a	0.201a	0.224a
	c	0.826a	0.412b	0.354b
	RMS	102.88	34.65	34.9
	Convergence	C	C	C
Inverse polynomial function	a	0.338a	0.355a	0.330a
	b	3.25b	4.88a	3.900b
	c	0.0333a	0.0281ab	0.0199b
	RMS	60.9	61.5	54.9
	Convergence	C	C	C
Exponential function	a	31.727a	24.509b	19.614b
	c	1.0222a	1.0223a	1.0228a
	RMS	266.4	63.2	36.2
	Convergence	C	C	C

RMS = Residual Mean Square; C = Converged; BS = Brown Swiss; WF = White Fulani; BSND = Brown Swiss x N'Dama crosses.

In Table 2, initial milk yield was zero for the estimated variables, as they do not take into consideration the yield of colostrums after birth. Time to peak yield estimated from the inverse polynomial was highest for the three breeds ranging between 23.10 and 42.75 days as compared to the estimated variables from the incomplete gamma (6.33-10.18) and exponential (19.18-31.04).

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Comparing estimated peak milk yield from exponential function with others, incomplete gamma and inverse polynomial has higher peak milk yield (ranging from 41.88-86.39kg and13.42-42.26kg respectively). Incomplete gamma had a more constant value in persistency for the three breeds considered.

However, the persistency value of inverse polynomial was lowest compared to incomplete gamma. Incomplete gamma function estimated between 4.09 and 4.62 persistency levels for the three breeds. Exponential function estimated between 3.479 and 2.999 while inverse polynomial estimated between 1.89 and 2.05 persistency levels. Incomplete gamma predicted early reach to peak yield with longer persistency followed by exponential and inverse polynomial. According to Gengler (1995), persistency of lactation yield is an important element of total yield and is advantageous because of better use of feed and reduction of stress to peak yield. Differences in persistency are a major factor that can cause total yield to differ even among dairy cows with the same peak yield.

For incomplete gamma, although Brown Swiss x N'Dama crossbred got to peak yield earlier than the other two breeds it had the lowest persistency of 4.09. White Fulani had the superior persistency of 4.62 with lower peak yield. Also in inverse polynomial, White Fulani had shorter time to peak and longer persistency than the other two breeds. Brown Swiss in exponential function got to peak yield later than the other two breeds but with better persistency. Kruip *et al.* (1996) stated that cows with flatter (i.e., with greater persistency) lactation curve should have fewer health and fertility problems than cows with higher peak yield and stepper rate of decline.

Table 2: Production variables as estimated from the curve parameter estimates of three functions

	Equation	Genotype Yield (kg)	Initial milk yield (kg)	Peak milk (days)	Time of peak	persistency
	Incomplete	BS	0	86.39	10.18	4.59
Gamma	WF	0	25.02	9.39	4.62	
	BSND	0	41.88	6.33	4.09	
Inverse	BS	0	13.52	42.75	1.91	
Polynomial	WF	0	23.10	23.10	2.05	
	BSND	0	42.26	42.26	1.89	
Exponential	BS	-	31.73	31.04	3.48	
	WF	-	24.51	23.97	3.22	
	BSND	-	19.62	19.18	3.00	

BS = Brown Swiss; WF = White Fulani; BSND = Brown Swiss x N'Dama crosses.

In Figure 1, the lactation curve estimated for all the equations in respect of Brown Swiss did not differ from one another. However, the three functions over estimated the lactation yield in the first few months. The inverse polynomial and exponential function later underestimated the mid lactation yield while only the incomplete gamma track well along the actual data. Critical examination of the graph revealed that only incomplete gamma gave the correct fitting of the graph for the data.

Figure 2 illustrated the curve for White Fulani. All the curves have their peak production at 60 days. The three functions track well along the actual graph. A yield of 60kg-63kg in the first month was predicted for all the functions and this slightly underestimated the actual yield by 5kg. however, post partum peak was reached at between first and second month of lactation. Also the day at which peak production was estimated to occur was some 120 days. For the inverse polynomial and exponential function the predicted yield in the first month was 430kg each while incomplete gamma had 500kg.

The three lactation curves obtained in Figure 3 for Brown Swiss x N'Dama crossbred were closely related in shape and length following closely with the actual curve generated. The day at which peak production occurred was 120 days and a yield of between 175-185kg was predicted for the first month. Although the pattern of the lactation curves for all the functions examined were some how similar throughout the lactation period, they underestimated milk yield between the fifth to eight month of lactation. The peak yield for all the functions were reached in the fourth month post partum followed by a gradual decline till the end of lactation.

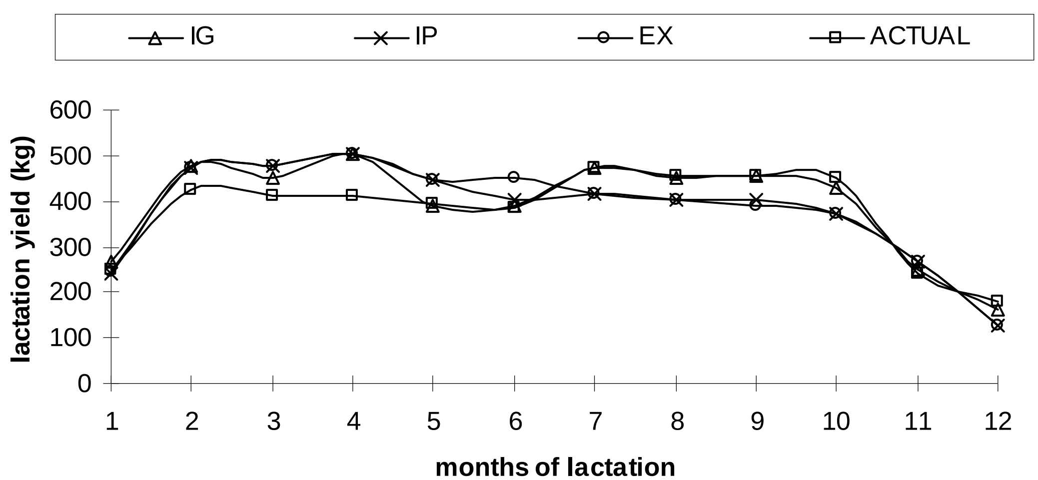

Fig. 1: Lactation curves for Brown Swiss using three functions

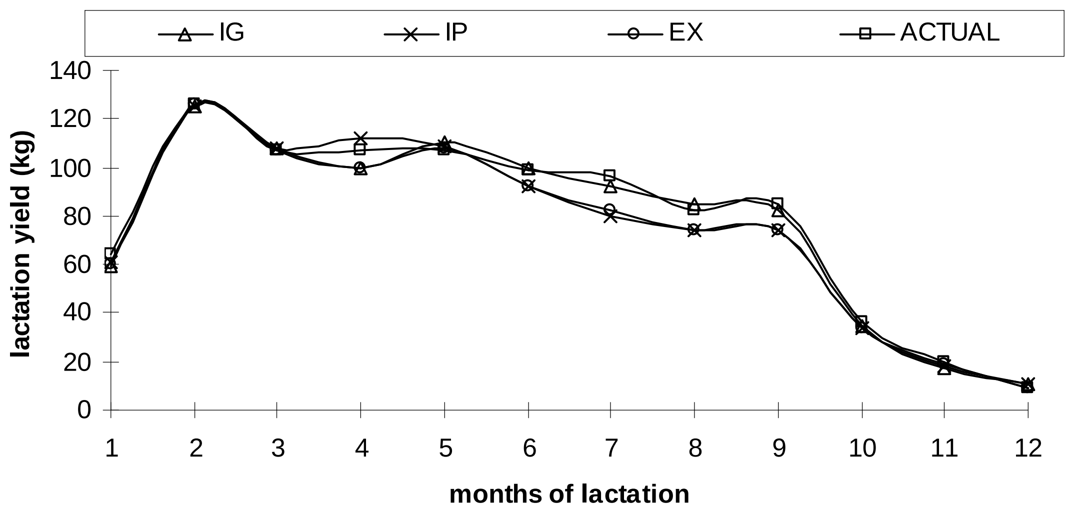

Fig. 2: Lactation curves for White Fulani using three functions

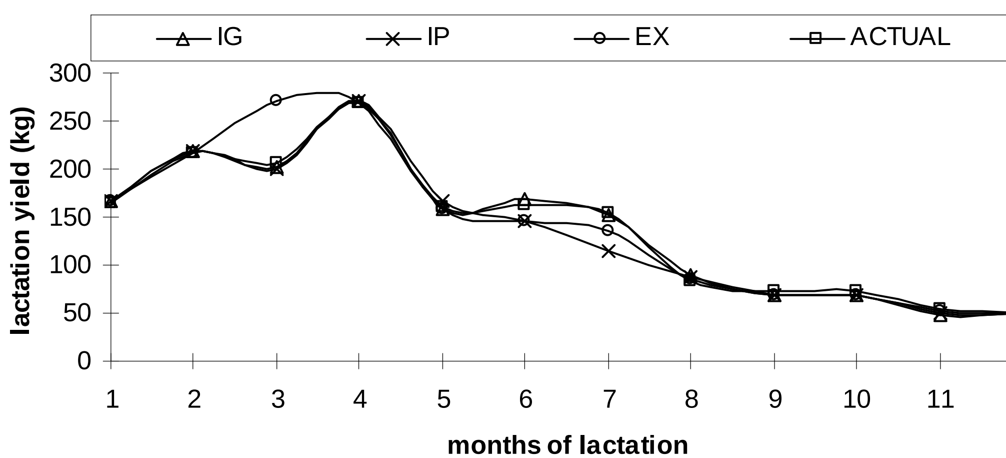

Fig. 3: Lactation curves for Brown Swiss x N'Dama using three functions

CONCLUSION

Lactation curve show the peak production level, persistency and the effect of specific event on milk yield. From the result of this study, it could be concluded that no matter the function used the graph will be the same for all the breed group. So dairy farmers who choose to use any function based on simplicity or convenience will always achieve similar result. The result also showed late arrival to peak according to breed groups considered while on the general view considering persistency, White Fulani performed better on the three functions followed by Brown Swiss.

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