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THE USE OF GAMMA-TYPE FUNCTION IN DESCRIBING THE LACTATION CURVE OF EGYPTIAN BUFFALOES

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SUMMARY

A total number of 1115 weekly milk records representing the first six lactations of 205 Egyptian buffaloes were used in this study. Data were collected over 11 years (1980-1990) from two farms. The gamma-type function suggested by Wood (1967) was used for describing the shape of lactation curve and its constants. The other traits related to lactation curve (week of peak yield, peak milk yield, and persistency of lactation) were also estimated according to Wood (1967). The effects of parity, farm, season of calving, year of calving on lactation curve constants and other traits were assessed.

The overall average of initial milk yield was significantly ($P<0.0001$) lower in the first lactation than in subsequent ones. Animals in the two farms and two seasons of calving had almost the same initial milk yield. The rate of increase during the ascending phase declined gradually by advancing parity. Animals in the two farms had also similar ascending phase. Winter calvers needed longer times to attain peak compared to summer calvers but the difference was not significant.

Milk yield during the descending stage decreased insignificantly by increasing parity. First calvers had significantly ($P<0.0001$) lower peak milk yield than older ones. First lactation peak week occurred significantly ($P<0.003$) earlier as compared with subsequent lactations. First calvers had lower persistency than subsequent lactations up to the

fifth parity. Differences in all traits studied due to year of calving and all the interactions studied were insignificant in most cases.

Keywords: Lactation curve, Egyptian buffaloes, gamma-type function

INTRODUCTION

The term 'lactation curve' refers to the graphical representation of the relationship between milk yield and length of time since calving. When a functional form is used to describe a lactation curve, then the milk yield at any given stage of lactation can be predicted. Such prediction, if accurate, can be used as a basis for early decisions to cull animals or to retain them for breeding stock (Papajcsik and Bodero, 1988).

The gamma function proposed by Wood (1967) is commonly used for describing the lactation curve in dairy cattle. In Egyptian buffaloes, Ragab et al. (1973), Soliman (1976), Samak et al. (1988), Mansour et al. (1993) and Metry et al. (1994) described the lactation curve. Few of them (Samak et al., 1988 and Mansour et al., 1993) used the gamma function in their studies.

The purpose of this study was to describe the lactation curve of Egyptian buffaloes according to the gamma function (Wood, (1967)), and test the effects of parity, farm, season, and year of calving on the lactation curve constants and other related traits.

DATA AND ANALYSIS

A total number of 1115 milk records representing the first six lactations of 205 Egyptian buffaloes were used in this study. Data were collected over 11 years (1980-1990) from two farms belonging to the Animal Production Research Institute (APRI), Ministry of Agriculture, Egypt. Animals were kept under the system of feeding and management adopted by the APRI. Green fodder was offered only during winter and spring where Egyptian clover (Trifolium alexandrnium) was available for grazing. However, in summer concentrates were offered twice before milkings according to the animal body weight and its milk production. Rice straw was available ad libitum only during summer and autumn seasons. Animals were

naturally mated and hand milked. Weekly milk yield was the sum of the daily production during the seven days of the week. Monthly milk yield was calculated as the sum of four-weeks milk production. Total milk yield was taken as the sum of the monthly milk production during the lactation length.

The gamma-type function suggested by Wood (1967) for describing the lactation curve was used as follows:

$$Y_n = an^b e^{-cn}$$

where:

Y_n is the total milk production (kg) in the n^{th} wk, a is the initial milk yield (kg), b describes the rate of milk production increase to peak during the ascending phase (kg/wk), c describes the rate of milk yield decrease during the descending phase and e is base of natural logarithms. The constants a, b and c were estimated for each lactation by the least squares method.

The traits related to the shape of lactation curve (the week of peak yield (wk), (pw= b/c); the peak milk yield (kg), (py= $a(b/c)^b e^{-b}$) and persistency of lactation (S=-(b+1)$\log_e$ c) were also estimated according to Wood (1967).

Data were analyzed by the least squares analysis of variance using the General Linear Models Procedure of the Statistical Analysis System (SAS, 1990). The effect of parity, farm, season of calving, year of calving and the interactions between parity and each of farm and season of calving and between farm and season of calving on the lactation curve constants and the other related traits were tested according to the following model:

$$Y_{ijklm} = \mu + P_i + F_j + S_k + Y_l + PF_{ij} + PS_{ik} + FS_{jk} + E_{ijklm}$$

where:

Y_{ijklm} = The observation on the m^{th} animal calved in the ith parity in the jth farm in the kth season of calving in the lth year of calving

μ = Overall mean.

P_i = The effect due to the parity, (i=1, 2,., 6)

F_j = The effect due to the farm, (j=1,2); 1= Mehallet Mousa; 2= El-Nattaf El-Gedid.

S_k = The effect due to the season of calving, (k=1,2) where; 1= winter (November- April) and 2 = Summer (May-October).

Y_l = The effect due to the year of calving, (l=1,...,11), l=1980, ... 1990.

PF_{ij} = The interaction between parity and farm.
PS_{ik} = The interaction between parity and season of calving.
FS_{jk} = The interaction between farm and season of calving.
E_{ijklm} = The error term.

RESULTS AND DISCUSSION

The overall mean of initial milk yield (constant "a" of the lactation curve) was 46.8 kg. It was significantly ($P<0.0001$) lower in the first lactation (37.2 kg) than in subsequent ones till the fourth lactation (52.9 kg), then it gradually decreased to reach 48.5 kg for the six calvers (Table 1 and Fig. 1). The significant influence of parity on this trait was also reported by Soliman (1976), Mourad (1984), Mourad et al. (1990) and Mansour et al. (1993) on Egyptian buffaloes. Animals in the two farms and two seasons of calving had similar initial milk yield (Table 1 and Figures 2 and 3). Also, differences in initial milk yield among years of calving were statistically nonsignificant.

The least squares mean of the rate of milk production increase during the ascending phase (constant "b" of the lactation curve) was 0.33 kg/wk, a value similar to that obtained by Kumar and Bhat (1979), (0.30) on Indian buffaloes and Gondal and Rowlinson (1984),(0.31) on Pakistani buffaloes. A gradual decrease was found in the rate of increase by advancing parity (from 0.37 kg/wk in the first parity till 0.31 in the fifth lactation), but the differences did not reach the level of significance. This explains that animals of older ages needed longer periods to reach the peak as compared with those of younger ages (Figure 1).

No significant differences in the rate of increase due to farm were detected, where animals in the two farms had also almost the same ascending phase of the lactation curve (Figure 2). Animals calved in winter needed longer times to attain peak compared to summer calvers (Figure 3), though the differences did not reach the level of significance. The effect of year of calving and interactions studied on constant constant "b" were all insignificant.

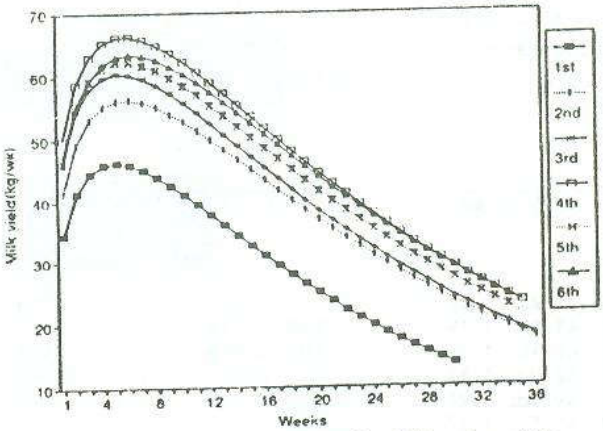

Fig. 1. Lactation curve for animals of different parities

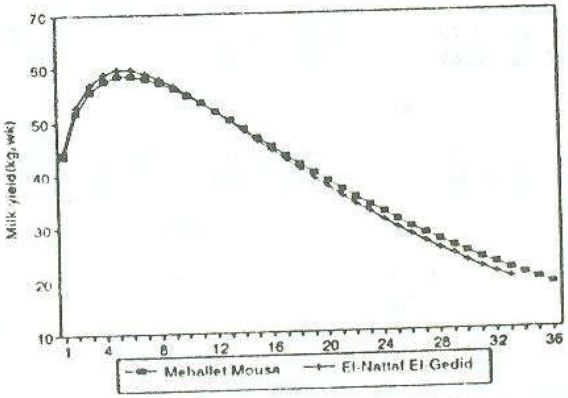

Fig. 2. Lactation curve for animals in two farms

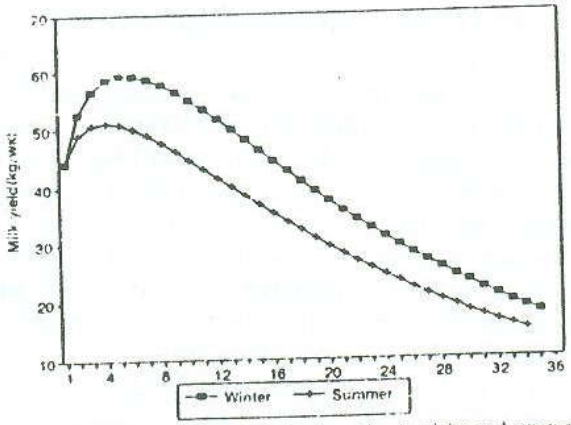

Fig. 3. Lactation curve for animals calving in winter and summer

Table 1. Least squares means (X) and standard errors (SE) of initial milk yield (the constant "a"), rate of increase to peak (the constant "b") and rate of decline (the constant "C")

		a			b			c		
	N	X	SE	P<F	X	SE	P<F	X	SE	P<F
Overall mean	1115	46.8	0.46		0.33	0.007		0.06	0.001	
Parity (P)				0.0001			NS			NS
1st	205	37.2a	1.40		0.37a	0.021		0.08a	0.004	
2nd	203	43.8b	1.19		0.34ab	0.018		0.06b	0.003	
3rd	199	49.1c	1.16		0.31b	0.018		0.06b	0.003	
4th	181	52.9d	1.11		0.31b	0.017		0.06b	0.003	
5th	169	49.9dc	1.21		0.31b	0.019		0.06b	0.003	
6th	158	48.5c	1.37		0.33b	0.021		0.06b	0.004	
Farm (F)				NS			NS			NS
Mehalt Mousa	525	46.3a	0.79		0.32a	0.012		0.06a	0.002	
El-Nattaf El-Gedid	590	47.5a	0.69		0.33a	0.011		0.06a	0.002	
Season of calving(S)				NS			NS			NS
Winter	621	47.1a	0.67		0.34a	0.010		0.06a	0.002	
Summer	494	46.7a	0.75		0.32a	0.011		0.06a	0.002	
Year of calving				NS			NS			NS
P * F				0.02			NS			NS
P * S				NS			NS			NS
F * S				NS			NS			NS

Winter season include months from Nov. to April.
Sumer season include months from May to Oct.

The overall average of the rate of decline of milk yield during the descending stage (constant "c") was 0.06 kg/wk (Table 1), an estimate equals that obtained by Mansour et al. (1993) on Egyptian buffaloes. Though the rate of decline decreased by increasing parity (Figure 1), the analysis of variance showed nonsignificant effect of parity on constant "c". No significant differences in the rate of decline due to farm, season of calving or all interactions studied were detected. The significant influence on this trait was observed only with year of calving (P<0.007).

The peak milk yield (the maximum weekly milk production) averaged 59.5 kg and peak week (time required to attain this peak) was 6.1 weeks (Table 2).

First calvers had significantly (P<0.0001) lower peak milk yield than older ones. First lactation peak week was accrued significantly (P<0.003) earlier as compared with the subsequent lactations (Table 2), indicating that the time required to reach maximum weekly milk yield increased with parity (Figure 1). Differences in peak yield and peak week between the two farms did not reach the level of significance (Table 2 and Figure 2). However, season of calving affected significantly (P<0.05) only peak week, where winter calvers had longer time compared to summer calvers to reach maximum milk yield (Table 2 and Figure 2). The significant influence of year of calving was observed only in peak week (P<0.02).

Table 2. Least squares means (X) and standard errors (SE) of peak milk yield (PY), peak week (PW) and persistency of lactation

	(PY)				(PW)			Persistency		
	N	X	SE	P<F	X	SE	P<F	X	SE	P<F
Overall mean	1115	59.5	0.51		6.1	0.08		63.3	1.29	
Parity (P)				0.0001			0.003			0.002
1st	205	46.5a	1.55		5.2a	0.24		48.5a	3.93	
2nd	203	56.3b	1.31		6.2b	0.21		65.5b	3.34	
3rd	199	60.9c	1.28		6.4b	0.20		68.9b	3.25	
4th	181	66.7d	1.23		6.3b	0.19		63.7b	3.12	
5th	169	62.7c	1.33		6.3b	0.21		67.1b	3.38	
6th	158	64.0dc	1.52		6.5b	0.24		66.4b	3.85	
Farm (F)				NS			NS			NS
Mehalt Mousa	525	59.2a	0.87		6.2a	0.14		66.2a	2.20	
El-Nattaf El-Gedid	590	59.9a	0.76		6.0a	0.12		60.5b	1.93	
Season of calving(S)				NS			0.05			0.02
Winter	621	59.9a	0.74		6.3a	0.12		66.5a	1.88	
Summer	494	59.2a	0.82		6.0b	0.13		60.1a	2.09	
Year of calving				NS			0.02			NS
P * F				NS			NS			NS
P * S				NS			NS			NS
F * S				NS			NS			NS

Concerning persistency of lactation, the results

indicated that parity had a highly significant (P<0.002) influence on persistency, where first calvers had lower value (48.3%) than subsequent lactations up to the fifth parity (67.1%). The increase of persistency of lactation by parity (Table 2 and Figure 1) could be explained by the decrease in the rate of decline by advancing parity (Table 1). The same trend was reported by Kumar et al. (1979). However, Soliman (1976), Samak et al. (1988) and Mansour et al. (1993), in Egyptian buffaloes, found an opposite trend, where the persistency of the first calvers was higher than those in the later lactations. Winter calvers were more persistent (66.5%) than summer ones (60.1%) and the differences were significant (P<0.02) (Figure 3). However, the effects of farm, year of calving and the interactions studied were all nonsignificant.

It could be concluded that the sequence of calving was the most important non-genetic factor causing variation in the shape of the lactation curve.

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إستخدام معادلة جاما فى وصف منحنى الحليب فى الجاموس المصرى .

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أجريت هذه الدراسة على ١١١٥ سجل لإنتاج اللبن الأسبوعى لعدد ٢٠٥ جاموسة فى مزرعتين تابعتين لمعهد بحوث الإنتاج الحيوانى - وزارة الزراعة . وقد شملت البيانات الستة مواسم الحليب الأولى خلال الفترة من ١٩٨٠ حتى ١٩٩٠. وكان الهدف من هذه الدراسة هو إستخدام معادلة جاما المقترحة بواسطة (Wood 1967) فى وصف منحنى الحليب للجاموس المصرى وكذلك دراسة العوامل الغير وراثية (الموسم - المزرعة - فصل وسنة الولادة) التى تؤثر على مكونات منحنى الحليب (إنتاج اللبن الأولى - معدل الزيادة حتى أقصى إنتاج لبن أسبوعى -معدل النقص بعد أقصى إنتاج لبن أسبوعى) والصفات المرتبطة به (أقصى إنتاج لبن أسبوعى - أسبوع أقصى إنتاج - المثابرة).

وتلخصت أهم النتائج فيما يلى :

١- كان متوسط انتاج اللبن المبدئى (الاولى) أقل فى الموسم الاول عن باقى المواسم التالية (بمستوى معنوية ٠,٠٠١) ولم تتأثر هذه الصفة معنويا بكل من المزرعة وفصل الولادة.

٢- وجد ان معدل زيادة إنتاج اللبن خلال مرحلة الصعود من منحنى الحليب يقل تدريجيا بتقدم موسم الحليب. وكانت حيوانات المزرعتين لها نفس شكل مرحلة الصعود تقريبا.

٣- تبين أن ولادات الشتاء تحتاج لفترة أطول للوصول إلى أقصى إنتاج مقارنة بولادا ت الصيف إلا أن الفروق كانت غير معنوية .

٤- تناقص إنتاج اللبن فى مرحلة الهبوط من منحنى الحليب بتقدم الحيوان فى العمر ، ولكن بفروق غير معنوية .

٥- تحقق أقصى إنتاج أسبوعى لحيوانات الموسم الأول عند ٥,٢ أسبوع وهو أقل معنويا مقارنا بالمواسم التالية.
٦- كانت المثابرة فى الموسم الاول أقل من مثيلاتها فى المواسم التالية .
٧- كان تأثير سنة الولادة والتداخلات بين العوامل المختلفة التى درست على معظم الصفات المدروسه غير معنويا .

أتاحة معادلة جاما فرصة رسم منحنى حليب قياسى للجاموس يسهل من إجراء المقارنات بين المزارع أو المواسم المختلفة أو أى عوامل آخرى من خلال عرض الرسومات. كما أمكن وصف المنحنى من خلال مكونات سهلت من دراسة تأثير العوامل المختلفة عليها وعلى الصفات الآخرى المرتبطة بمنحنى الحليب.

أوضحت النتائج أن الموسم هو أهم العوامل الغير وراثية التى تؤثر على شكل منحنى الحليب وعلى مكوناته والصفات المرتبطة به.