Egyptian J. Anim. Prod. (1998) 35 (1): 1-27.

ESTIMATION OF LACTATION CURVE PARAMETERS IN EGYPTIAN BUFFALOES

R. R. Sadek[1], Mahasin, M. Mohamed[2], M. A. M., Ibrahim[1] and Hoda, M. A. Abdel-Lattef[2]

1-Department of Animal Production, Faculty of Agriculture, University of Cairo,
2- Animal Production Research Institute, Ministry of Agriculture, Cairo, Egypt

SUMMARY

Total of 2158 lactation records, representing six parities were collected on 364 Egyptian buffaloes over 16 years from two farms. The records were classified into five groups according to the length of lactation starting from 12 weeks and ending with periods greater than 44 weeks with 8 week intervals. The study aimed at using the gamma-type function in estimating lactation curve parameters and describing the shape of the curve according to the length of lactation. The results showed that initial milk yield increased gradually with increasing lactation period. The rate of increase to peak yield was faster in animals of short lactation periods than those of long ones. The rate of decline decreased with increasing lactation period. Peak milk yield increased with increasing lactation period, the values started from 47.9 kg for animals lactating for 12-20 weeks and reached 65.5 kg for animals milking for greater than 44 weeks. Peak week was 4.7 weeks for animals milked 12-20 weeks, then it gradually increased by increasing the lactation period till reached 7.0 weeks in animals of 37-44 weeks. The persistency of lactation for animals milked 12-20 weeks was 29.2%, then it increased gradually by increasing the length of lactation till it reached 79.5% for animals of 37-44 weeks lactation period with an overall average of 65.7%. The overall averages of total milk yield and lactation period for all groups were 1505 kg and 261 day, respectively.

Keywords: Buffaloes, lactation curve parameters, gamma function

INTRODUCTION

Milk production increases from calving to peak then followed by a gradual decline until the animal goes dry. The graphical representation of milk production throughout the lactation period is the lactation curve. The shape of lactation curve is determined by peak yield, which is attained at about 60 days after parturition, and persistency of lactation. The description of the lactation curve assists the breeder to predict total milk yield from part lactations and to take early decisions for culling or selection. Many mathematical functions have been proposed to describe a part or the whole lactation curve in dairy cattle. Yadev *et al.* (1977), Kumar and Bhat (1979) suggested the use of gamma-type function for describing the lactation curve in dairy cattle and Indian buffaloes. Ali (1972), Ragab *et al.* (1973) and Soliman (1976) studied the genetic and non-genetic factors affecting lactation curve of Egyptian buffaloes. Samak *et al.* (1988), Mansour *et al.* (1993) and Ibrahom (1995) using gamma function, described the lactation curve for Egyptian buffaloes. The objective of this study was to estimate the parameters of the lactation curve and describe the shape of the curve in Egyptian buffaloes using gamma function according to the length of lactation period.

DATA AND ANALYSIS

The data used in this study were derived from 2158 lactation records collected on 364 Egyptian buffaloes from two buffalo farms located at Kafr El-Sheikh governorate and belonging to the Animal Production Research Institute, Ministry of Agriculture, Egypt. Data represented six parity classes and 16 years of calving (1975 - 1990). In this study, all records of lactation periods of at least 12 weeks were used. The records were classified into five groups according to the length of lactation starting from 12 weeks and ending with periods greater than 44 weeks with 8 week intervals as follows:

The first groups (G1) : Animals milking for 12-20 weeks.
The second groups (G2) : Animals milking for 21-28 weeks.
The third groups (G3) : Animals milking for 29-36 weeks.
The fourth groups (G4) : Animals milking for 37-44 weeks.
The fifth groups (G5) : Animals milking for >44 weeks.

The gamma-type function (Wood, 1967) was used for estimating the lactation curve parameters as follows:

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

where:

Y_n is the milk production (Kg) in the nth week (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.

Initial milk yield (parameter a) was calculated as :

$$a = Y/\sum^{L}_{n-1} n^b e^{-cn}$$

where: Y is total lactation yield, L is length of lactation.

The rate of increase to peak (parameter b) was estimated as:

$$b = Pc$$

where P is week of peak yield.

The rate of decrease after peak (parameter c) was calculated as:

$$c = Mq / (P - M)$$

where: q is average rate of decline at week M, $M = P+(L-P)/2$ (Wood, 1979).

The traits related to the shape of lactation curve (the week of peak yield, ($pw= b/c$); the peak milk yield (Kg), ($pmy= a(b/c)^b e^{-b}$), persistency of lactation ($S=-(b+1)\log_e c$), total milk yield (TMY) and lactation period (LP) were also estimated for each lactation period group according to Wood (1967).

The effect of sire, parity, season and year of calving, farm and the interactions between parity and each of farm and season of calving and between farm and season of calving on lactation curve parameters and related traits were tested. The following model, using LSMLMW and MIXMDEL program (Harvey, 1990) was used.

$$Y_{ijklmn} = \mu + s_i + p_j + f_k + sn_l + y_m + pf_{jk} + psn_{jl} + fsn_{kl} + e_{ijklmn}$$

where:

Y_{ijklmn} = The observation on the n^{th} animal of the i^{th} sire calved in the j^{th} parity in the k^{th} farm in the lth season of calving in the m^{th} year of calving,

μ = Overall mean,

s_i = The random effect of sire, assumed to be normally and independently distributed with 0 mean and variance 2, i=1, ..., 83,

p_j = The fixed effect due to the j^{th} parity, (j=1, 2,....., 6) where; animals of parities higher than 5 were grouped in the 6th class,

f_k = The fixed effect due to the farm, (k=1,2); 1= Mehallet Mousa; 2= ELNattaf El-Gedid,

sn_l = The fixed effect due to the season of calving, (l=1,2) where; 1 = winter (Nov.- April) and 2 = Summer (May - Oct.),

y_m = The fixed effect due to the year of calving, (m=1,...,16; 1975-1990),

pf_{jk} = The interaction between parity and farm.

psn_{jl} = The interaction between parity and season of calving.

fsn_{kl} = The interaction between farm and season of calving.

e_{ijklmn} = The error term.

RESULTS AND DISCUSSION

A. Lactation Curve Parameters:

1. Initial Milk Yield (Parameter "a")

The overall average of initial milk yield (parameter a) measured on 2158 records for all groups together was 45.9 kg, a value almost close to that obtained by Ibrahim (1995, 46.8 kg) on Egyptian buffaloes. It could be observed that initial milk yield was 40.9 kg for G1, then it gradually increased by increasing lactation period till reached 53.2 kg for G5 (Table 1 and Figure 1). Initial milk yield was found to increase with advancing parity from the first till the fifth lactation in all groups except G5 (Table 1 and Figures from 2-7). The same trend was also reported by Soliman (1976), Samak *et al.* (1988), Mansour *et al.* (1993) and Ibrahim (1995) on Egyptian buffaloes; Bhat and Kumar (1978) on Indian buffaloes and Cheema and Basu (1983) on Murrah buffaloes.

The test of significance of initial milk yield (Table 1) revealed that parity had a highly significant effect on initial milk yield in all lactation period groups studied except the first (G1). The probability levels of significance ranged between P<0.00001 and P<0.02. Buffaloes in the two farms produced almost the same initial milk yield in G2, G4 and G5. Significant effect (P<0.03) of farm on initial milk yield was only observed in the case of G3, where animals of farm 2 produced higher initial milk yield (45.9 kg) than those of farm 1 (42.1 kg) (see Table 1 and Figures from 8 to 13). Winter and summer calvers had also almost the same initial milk yield in all lactation period groups studied except for G1 (Table 1 and Figures from 14 to 19). Differences in initial milk yield due to the effect of season of calving did not reach the level of significance (Table 1). No significant differences among years of calving were detected in this trait except for G3.

Table 1. Least square means (X ± SE) and test of significance of initial milk yield (the coefficient "a" of lactation curve, kg) for different lactation period groups

Classification	G1		G2		G3		G4		G5		All groups	
	N	X ± SE	N	X ± SE	N	X ± SE	N	X ± SE	N	X ± SE	N	X ± SE
Overall mean	216	40.9±1.4	293	40.5±1.4	519	43.7± 0.9	511	46.1±1.1	619	53.2±1.5	2158	45.9±0.6
Sire		NS		.01		.03		.02		NS		.003
Parity (p)		NS		.02		.00001		.00001		.00001		.00001
1st	66	32.5±3.5	62	34.9±2.5	63	35.0±2.2	61	37.0±2.6	112	43.8±2.9	364	35.5±1.2
2nd	24	44.1±4.2	41	41.4±2.4	71	41.2±1.8	78	37.8±2.2	155	52.6±2.4	369	43.3±1.0
3rd	58	43.6±3.4	74	42.0±2.0	122	47.5±1.4	152	49.0±1.6	200	50.2±2.1	606	46.6±0.8
4th	13	37.9±5.2	29	42.6±2.7	61	47.8±1.8	57	49.9±2.2	55	67.4±2.9	215	52.3±1.2
5th	17	40.8±4.8	26	43.4±2.9	48	48.5±2.1	43	52.6±2.7	41	53.1±3.3	175	50.3±1.3
>5th	38	46.6±4.3	61	38.7±2.9	154	42.4±2.1	120	50.4±2.5	56	52.1±4.2	429	47.4±1.3
Farm (f)		NS		NS		.03		NS		NS		Ns
1	90	44.1±2.3	143	41.0±1.7	298	42.1±1.1	301	46.4±1.4	441	53.6±1.7	1273	46.1±0.7
2	126	37.7±2.3	150	40.0±1.8	221	45.4±1.2	210	45.8±1.5	178	52.8±2.1	885	45.7±0.8
Season of calving(sn)		NS		NS		NS		NS		NS		NS
Winter	116	39.5±2.2	142	40.5±1.6	295	43.5±1.1	297	46.5±1.3	379	53.9±1.7	1229	46.6±0.7
Summer	100	42.3±2.2	151	40.4±1.6	224	43.9±1.1	214	45.7±1.4	240	52.5±1.8	929	45.2±0.7
Year of calving		NS		NS		.02		NS		NS		NS
p x f		NS		NS		NS		.04		NS		NS
p x sn		NS		NS		NS		NS		NS		NS
f x sn		NS		NS		NS		NS		NS		NS

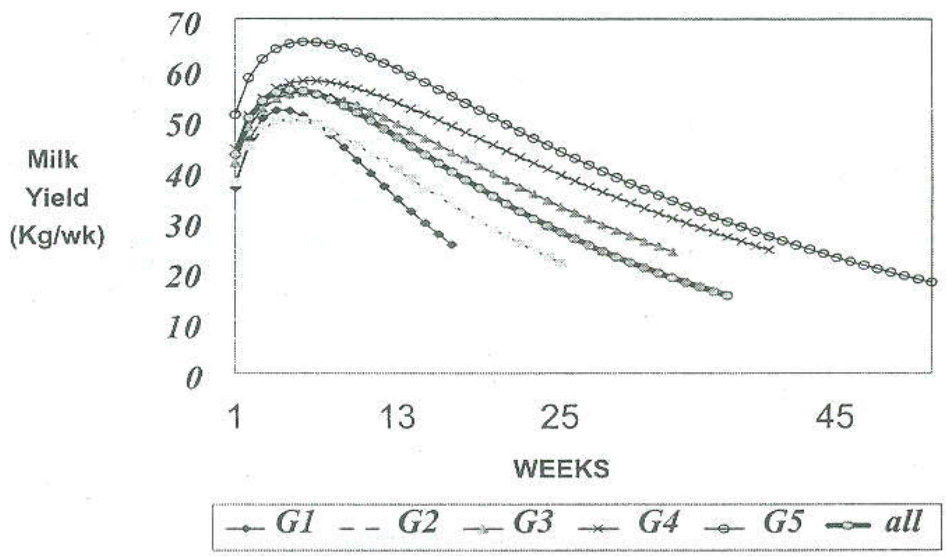

Fig 1. Lactation curve for animals of different lactation period groups.

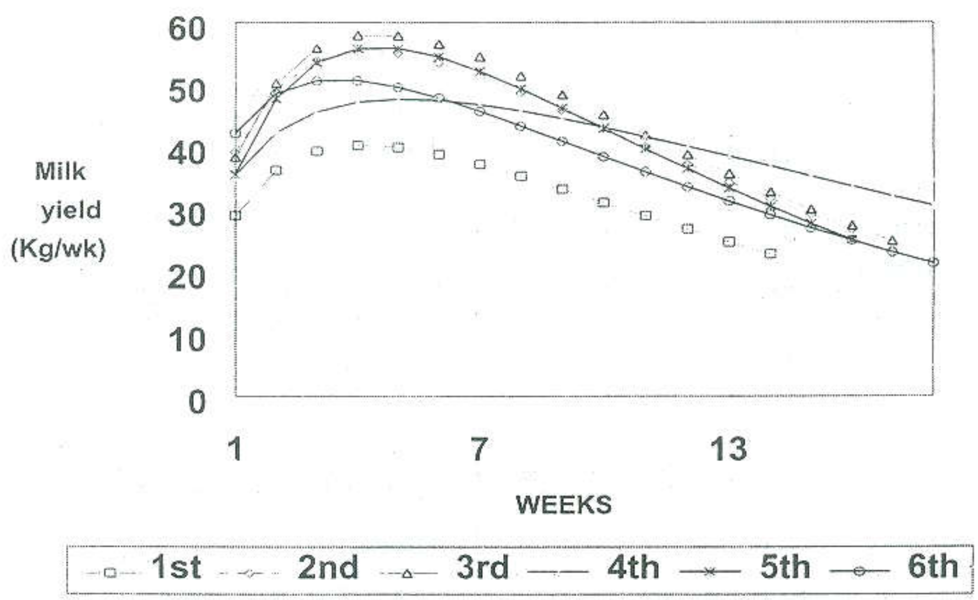

Fig 2. Lactation curve for animals of different parities dried-off normally at 12-20 week (G1).

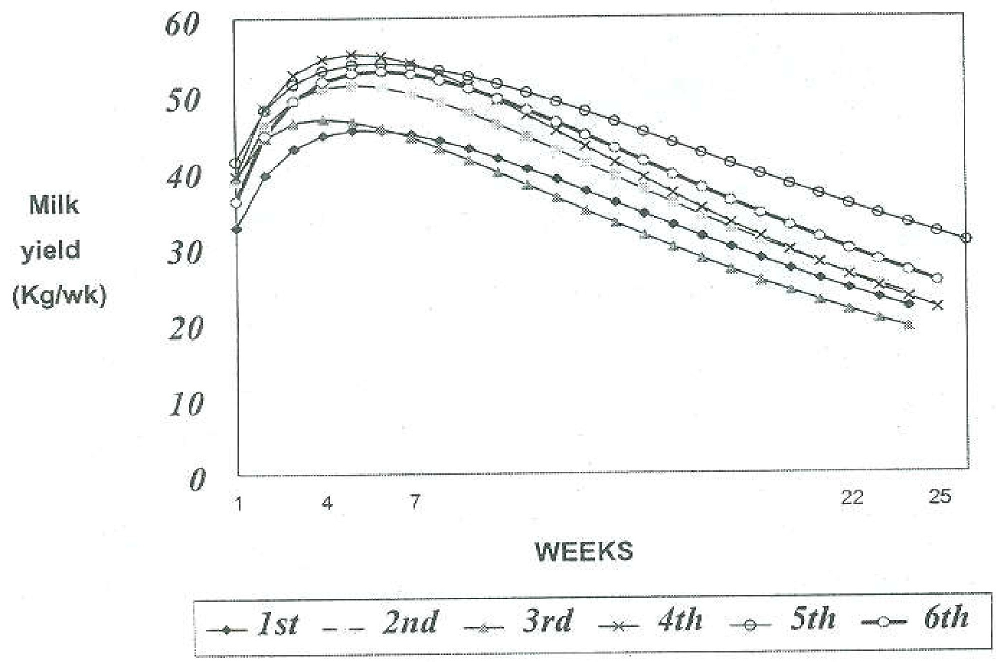

Fig 3. Lactation curve for animals of different parities dried-off normally at 21- 28 week (G2).

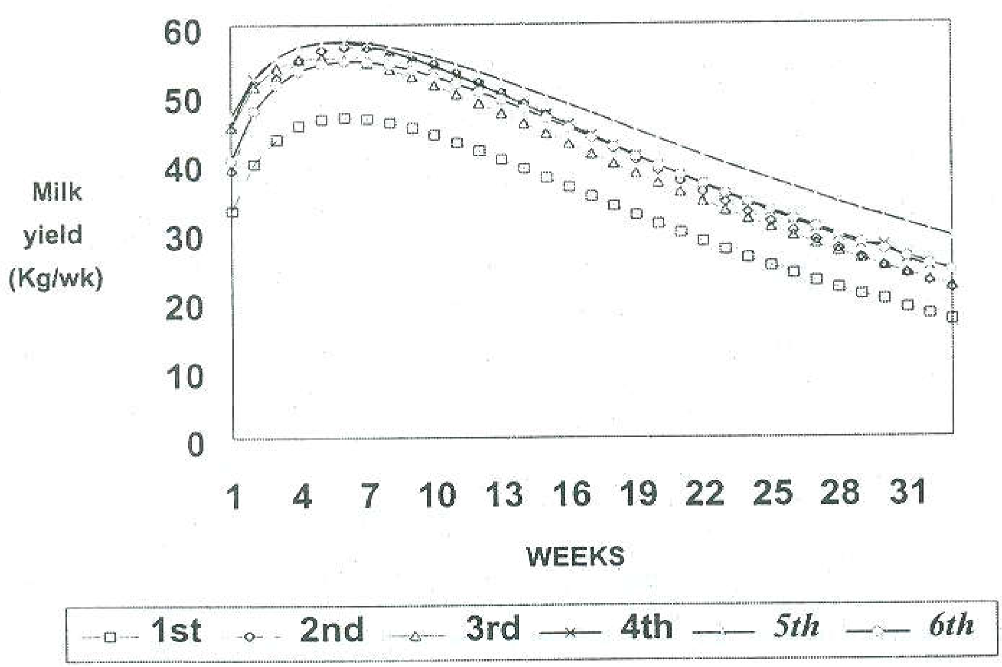

Fig 4. Lactation curve for animals of different parities dried-off normally at 29-36 week

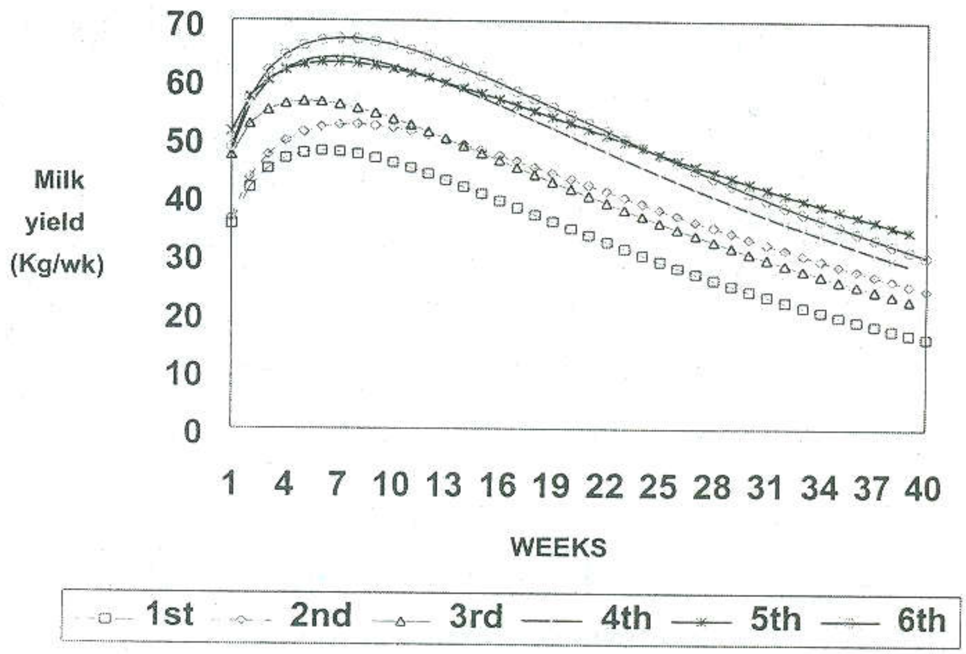

Fig 5. Lactation curve for animals of different parities dried-off normally at 37-44 week (G4).

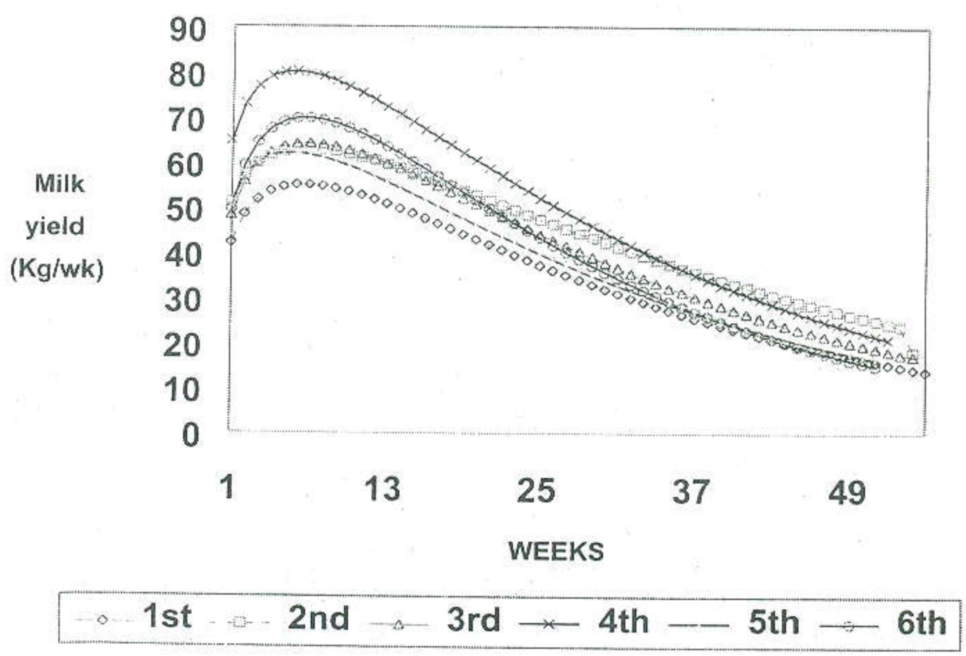

Fig 6. Lactation curve for animals of different parities dried-off normally at > 44 week (G5).

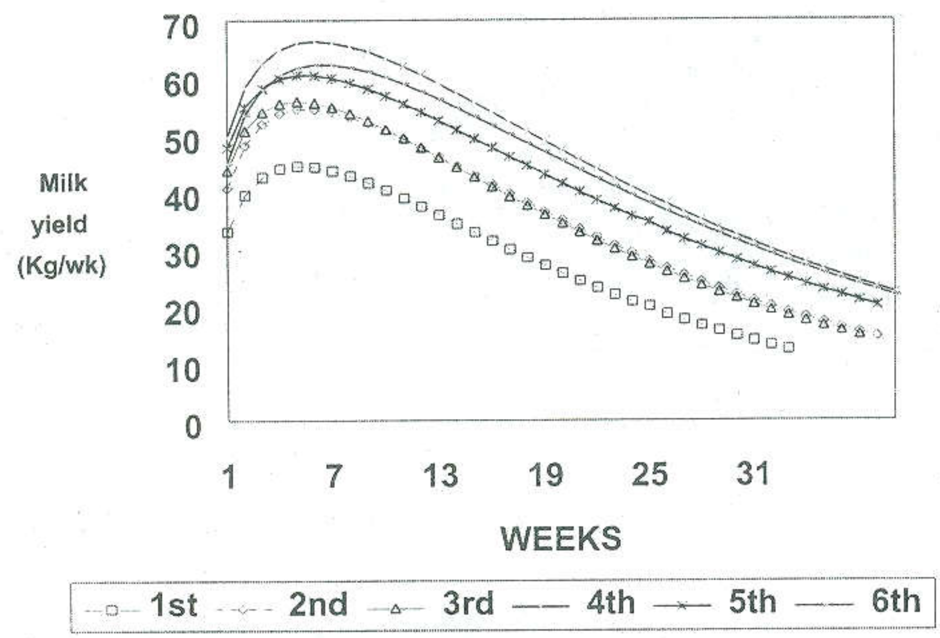

Fig 7. Lactation curve for animals of different parities (all groups).

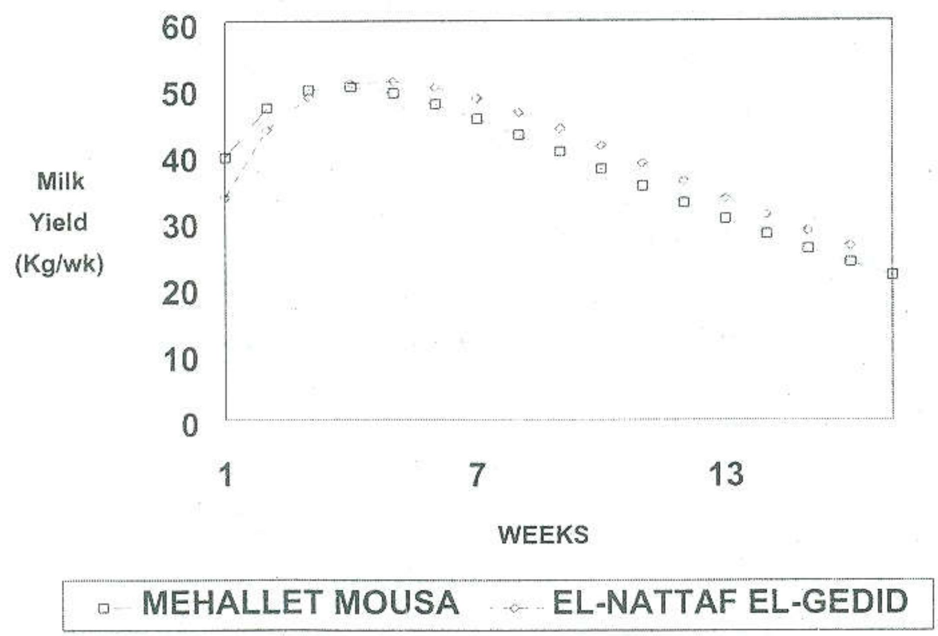

Fig 8. Lactation curve for animals of the two frms dried-off normally at 12-20 week (G1).

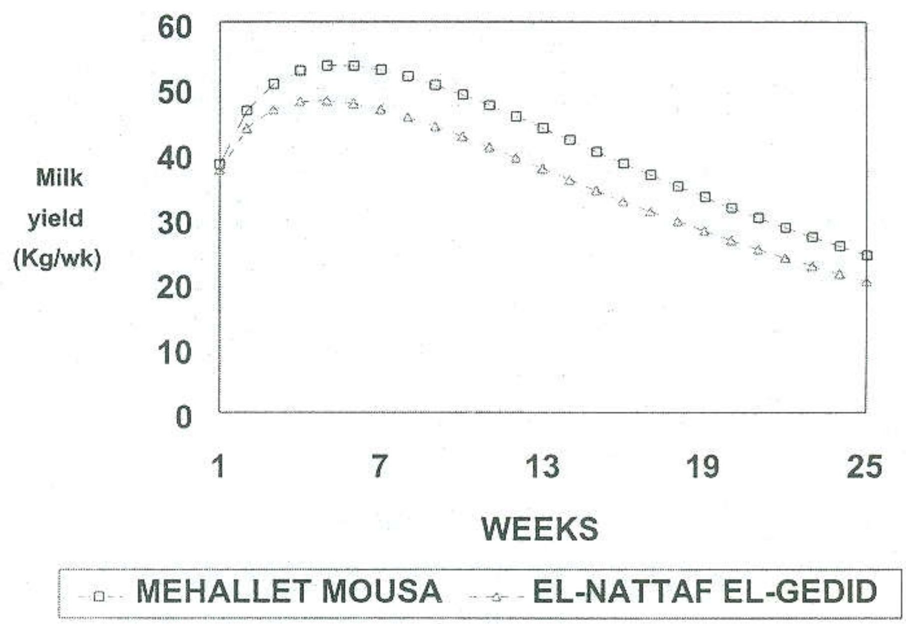

Fig 9. Lactation curve for animals of the two farms dried-off normally at 21-28 week (G2).

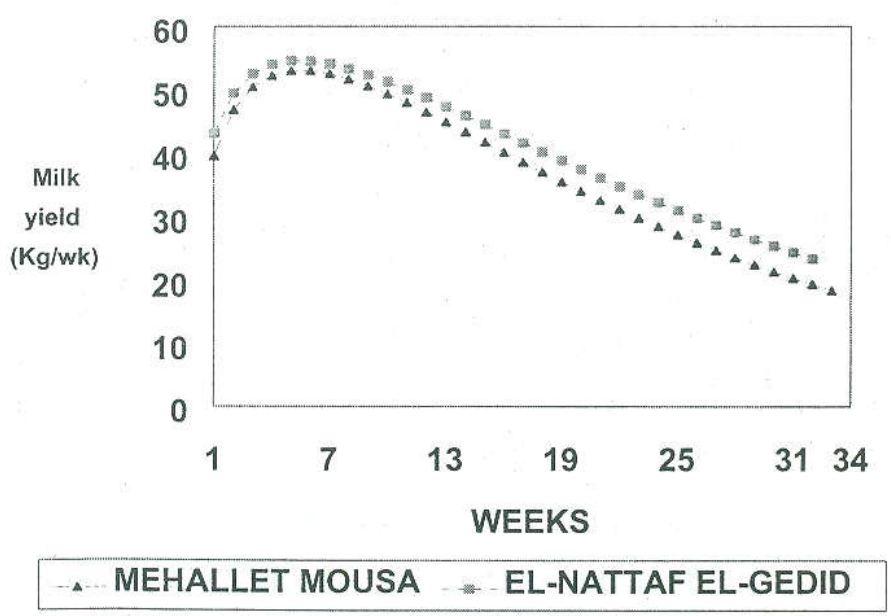

Fig 10. Lactation curve for animals of the two farms dried-off normally at 29-36 week (G3).

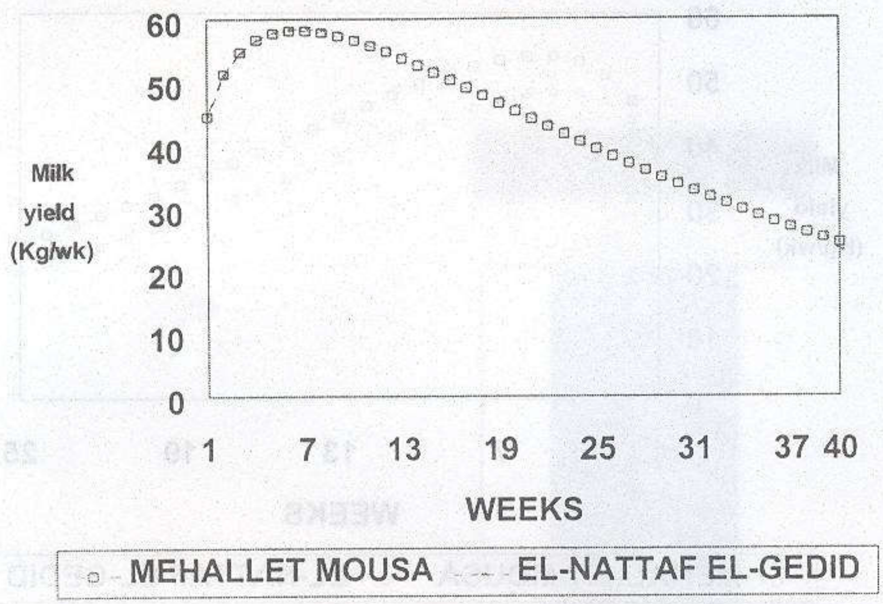

Fig 11. Lactation curve for animals of the two farms dried-off normally at 36-44 week (G4).

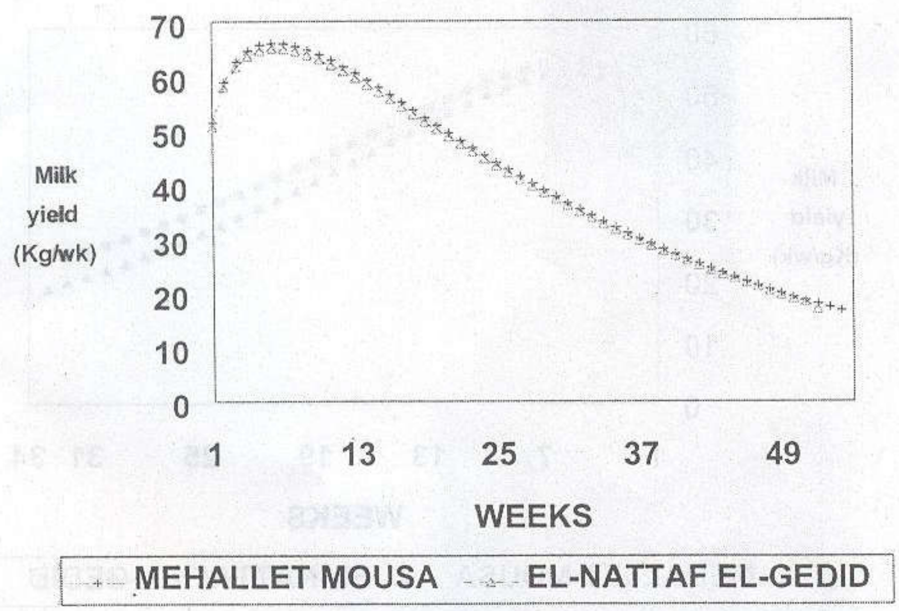

Fig 12. Lactation curve for animals of the two farms dried-off normally at >44 week (G5).

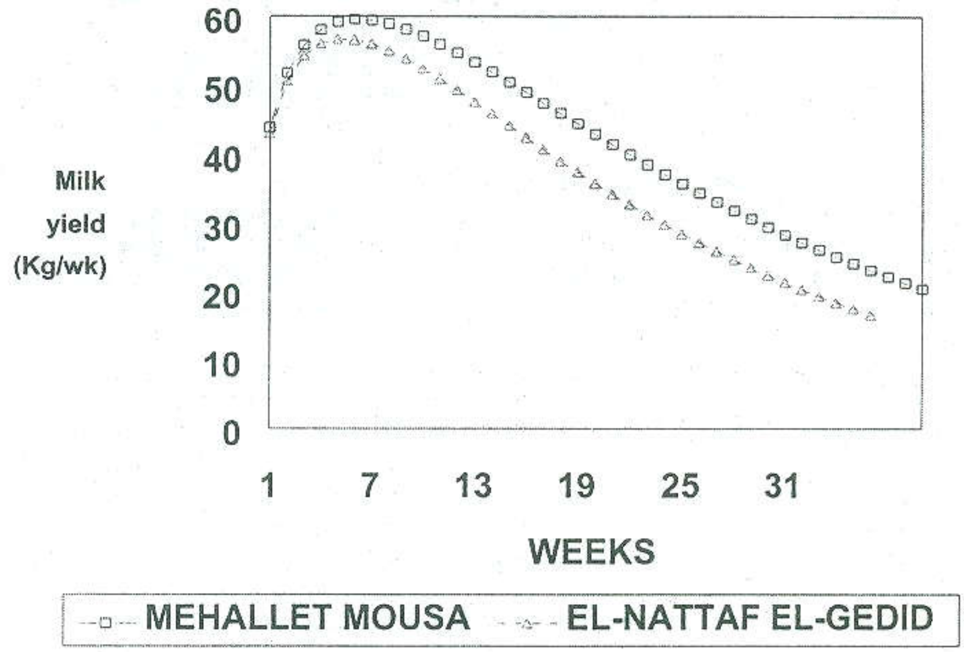

Fig 13. Lactation curve for animals of the two farms (all groups).

The interaction between parity and farm was not significant in all groups except for G4. The interactions between season of calving and each of parity and farm had also no significant influence on this trait in all lactation period groups studied. Sire had a highly significant effect on initial milk yield in all groups studied except the first (G1) and the fifth (G5) groups. The probability levels of significance ranged between P<0.003 and P<0.03.

2. The Rate of Increase to Peak (Parameter "b"):

The overall average of the rate of milk production increase during the ascending stage (parameter b), was 0.31 kg/wk (Table 2). This estimate is almost similar to the values obtained by Kumar and Bhat (1978, 0.30) on Indian buffaloes, Gondal and Rowlinson (1984, 0.31) on Pakistany buffaloes and Ibrahim (1995, 0.33) on Egyptian buffaloes.

The rate of increase of milk yield during the ascending stage of the lactation curve had a decreasing trend by increasing lactation period starting from 0.49 in G1 to 0.25 in G5 (Figure 1). This indicates that the rate of increase to peak yield is faster in animals of normal short lactation periods than those of long ones. Parity had a highly significant influence on the rate of ascending to peak in all lactation period groups studied except in G1 and G2. A gradual decrease was also observed in the rate of increase by advancing parity for all lactation period groups with some fluctuations (see Table 2 and Figures from 2 to 7). This means that animals of higher order of lactation needed longer periods to reach the peak as compared with those of younger ages.

As found in initial milk yield, no significant differences in the rate of increase due to farm were detected in all groups studied except the third (G3) where animals of the two farms had almost the same rate of increase during ascending stage (see Figures from 8 to 13). This may be attributed to the similarity in management practices of the two farms. The influence of year of calving was also not significant on this trait in all groups of lactation period studied except in G5.

The rate of ascending to peak for all lactation period groups studied was slower for animals which calved in summer than winter calvers except G3 (see Table 2 and Figures from 14 to 19), however, the differences did not reach the level of significance. contradicting results were obtained by Mansour *et al.* (1993) on the same breed where, summer calvers had higher values of the rate of increase than animals calving in winter.

No significant differences in the rate of increase to peak were detected among the interactions of parity and farm, parity and season of calving and farm and season of calving in all lactation period groups studied. Sire had a highly significant (P<0.00001) influence on this trait only in the second group (G2).

3. The Rate of Decline (Parameter "c"):

The overall average of the rate of decline of milk yield during the descending stage after peaking out (parameter c) was 0.06 kg/wk for all groups (Table 3), an estimate equal to that obtained by Mansour *et al.* (1993) and Ibrahim (1995) on the same breed. The highest rate of decline was that of G1 (0.11) and the lowest was that of G4 and G5 (0.04 in each) (Table 3 and Figure 1). This indicates that the rate of decline decreased with advancing lactation period (as found in the case of the rate of increase).

Table 2. Least square means (X ± SE)and test of significance of rate increase to peak (the coefficient "b" of lactation curve, kg/wk) for different lactation period groups

Classification	G1		G2		G3		G4		G5		All groups	
	N	X ± SE	N	X ± SE	N	X ± SE	N	X ± SE	N	X ± SE	N	X ± SE
Overall mean	216	0.49±1.4	293	0.35±1.4	519	0.30± 0.9	511	0.26±1.1	619	0.25±1.5	2158	0.31±0.6
Sire		NS		.00001		NS		NS		NS		.04
Parity (p)		NS		NS		.001		.004		.03		.02
1st	66	0.50±3.5	62	0.38±2.5	63	0.36±2.2	61	0.31±2.6	112	0.26±2.9	364	0.36±1.2
2nd	24	0.51±4.2	41	0.35±2.4	71	0.38±1.8	78	0.31±2.2	155	0.20±2.4	369	0.33±1.0
3rd	58	0.58±3.4	74	0.28±2.0	122	0.25±1.4	152	0.21±1.6	200	0.27±.02	606	0.30±0.8
4th	13	0.36±5.2	29	0.41±2.7	61	0.27±1.8	57	0.27±2.2	55	0.23±2.9	215	0.30±1.2
5th	17	0.63±4.8	26	0.29±2.9	48	0.23±2.1	43	0.20±2.7	41	0.22±3.3	175	0.27±1.3
>5th	38	0.5±4.3	61	0.41±2.9	154	0.31±2.1	120	0.29±2.5	56	0.33±4.2	429	0.32±1.3
Farm (f)		NS		NS		.02		NS		NS		NS
1	90	0.41±2.3	143	0.38±1.7	298	0.33±1.1	301	0.26±1.4	441	0.25±1.7	1273	0.31±0.7
2	126	0.56±2.3	150	0.33±1.8	221	0.27±1.2	210	0.27±1.5	178	0.25±2.1	885	0.32±0.8
Season of calving(sn)		NS		NS		NS		NS		NS		NS
Winter	116	0.53±2.2	142	0.36±1.6	295	0.29±1.1	297	0.28±1.3	379	0.26±1.7	1229	0.31±0.7
Summer	100	0.44±2.2	151	0.35±1.6	224	0.31±1.1	214	0.25±1.4	240	0.24±1.8	929	0.31±0.7
Year of calving		NS		NS		NS		NS		.05		.01
p x f		NS		NS		NS		NS		NS		NS
p x sn		NS		NS		NS		NS		NS		NS
f x sn		NS		NS		NS		NS		NS		NS

Table 3. Least square means (X ± SE) and test of significance of rate declince (the coefficient "c" of lactation curve, kg/wk) for different lactation period groups

Classification	G1		G2		G3		G4		G5		All groups	
	N	X ± SE	N	X ± SE	N	X ± SE	N	X ± SE	N	X ± SE	N	X ± SE
Overall mean	216	0.11±..007	293	0.07±..005	519	0.05± .002	511	0.04±..001	619	0.04±..002	2158	0.06±..002
Sire		NS		.01		.04		NS		NS		.0003
Parity (p)		NS		NS		.02		NS		NS		.001
1st	66	0.12±..014	62	0.07±..008	63	0.06±..005	61	0.05±..004	112	0.04±..004	364	0.07±..003
2nd	24	0.12±..016	41	0.07±..008	71	0.06±..005	78	0.04±..004	155	0.03±..003	369	0.06±..003
3rd	58	0.13±..014	74	0.07±..007	122	0.05±..004	152	0.04±..002	200	0.04±..003	606	0.06±..002
4th	13	0.07±..021	29	0.08±..008	61	0.05±..004	57	0.04±..004	55	0.04±..004	215	0.05±..003
5th	17	0.14±..019	26	0.05±..010	48	0.04±..005	43	0.03±..005	41	0.04±..005	175	0.05±..004
>5th	38	0.10±..017	61	0.07±..010	154	0.05±..005	120	0.04±.004	56	0.05±..006	429	0.05±..004
Farm (f)		NS		NS		NS		NS		NS		NS
1	90	0.11±..009	143	0.07±..006	298	0.06±..003	301	0.04±..002	441	0.04±..002	1273	0.05±..002
2	126	0.12±..009	150	0.07±..006	221	0.05±..003	210	0.04±..002	178	0.04±..003	885	0.06±..002
Season of calving(sn)		NS		NS		NS		NS		NS		NS
Winter	116	0.12±..009	142	0.07±..006	295	0.05±..003	297	0.04±..002	379	0.04±..002	1229	0.06±..002
Summer	100	0.11±.009	151	0.07±..006	224	0.05±..003	214	0.04±..002	240	0.04±..002	929	0.06±..002
Year of calving		.004		NS		NS		NS		.04		.00001
p x f		NS		NS		NS		NS		NS		NS
p x sn		NS		NS		NS		NS		NS		NS
f x sn		NS		NS		NS		NS		NS		NS

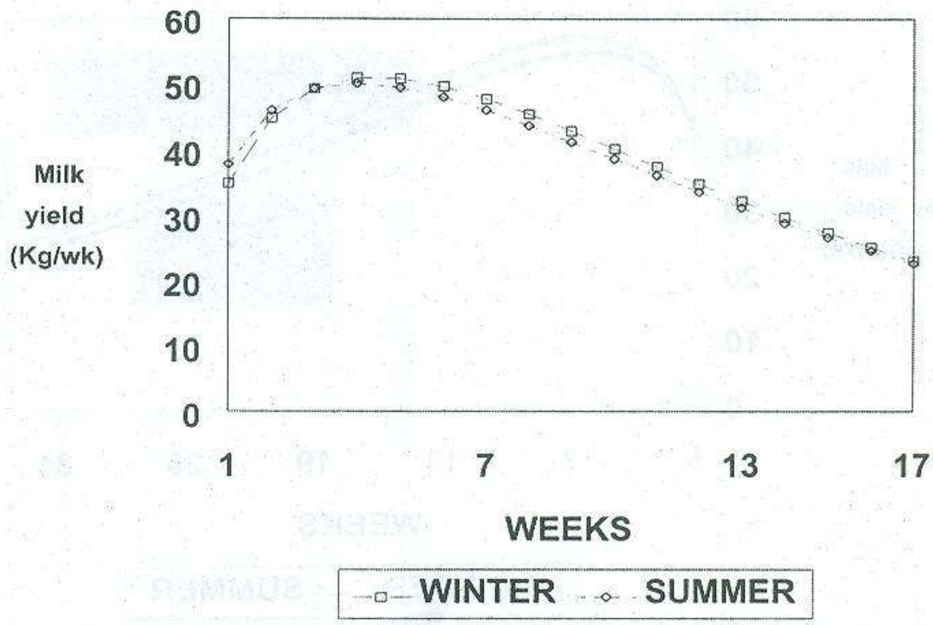

Fig 14. Lactation curve for animals of winter and seasons dried-off normally at 12-20 week (G1).

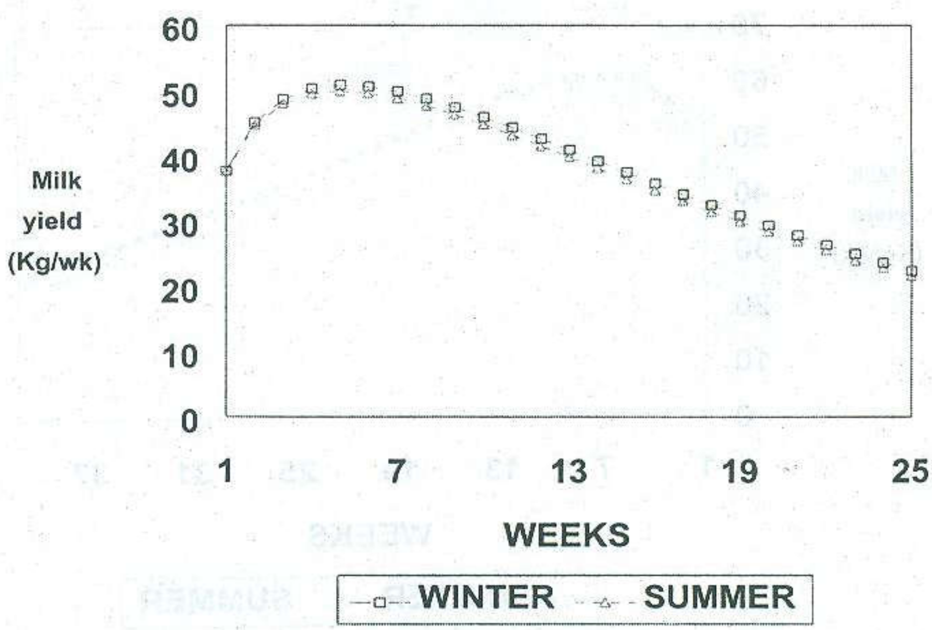

Fig 15. Lactation curve for animals of winter and seasons dried-off normally at 21-28 week (G2).

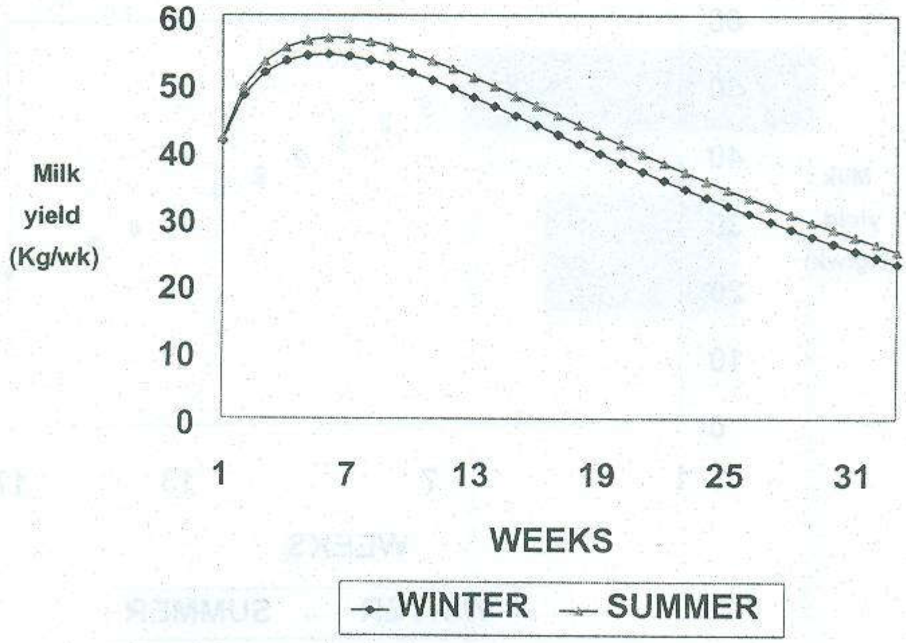

Fig 16. Lactation curve for animals of winter and seasons dried-off normally at 29-36 week (G3).

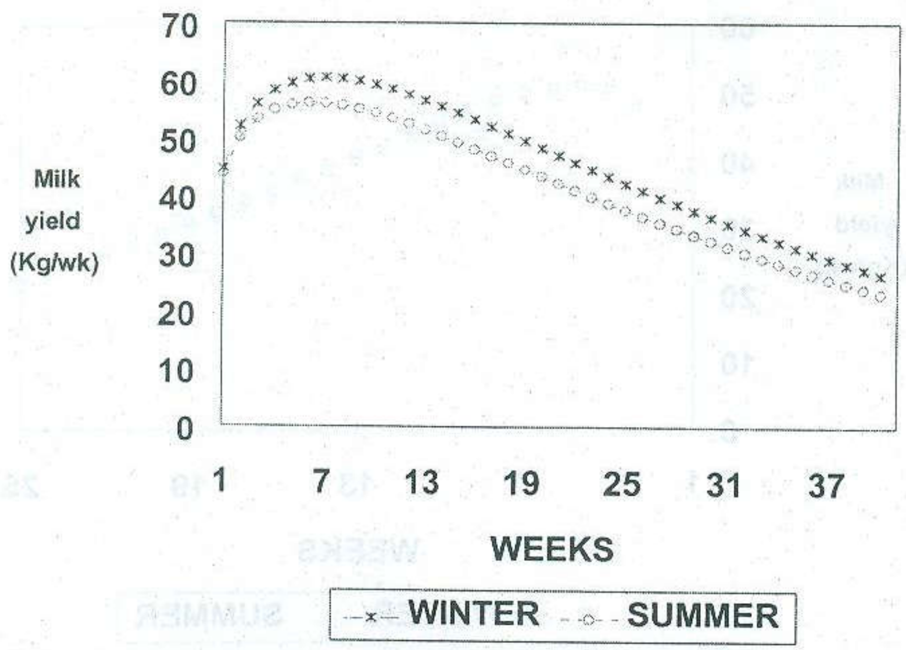

Fig 17. Lactation curve for animals of winter and summer seasons dried-off normally at 37-44 week (G4)

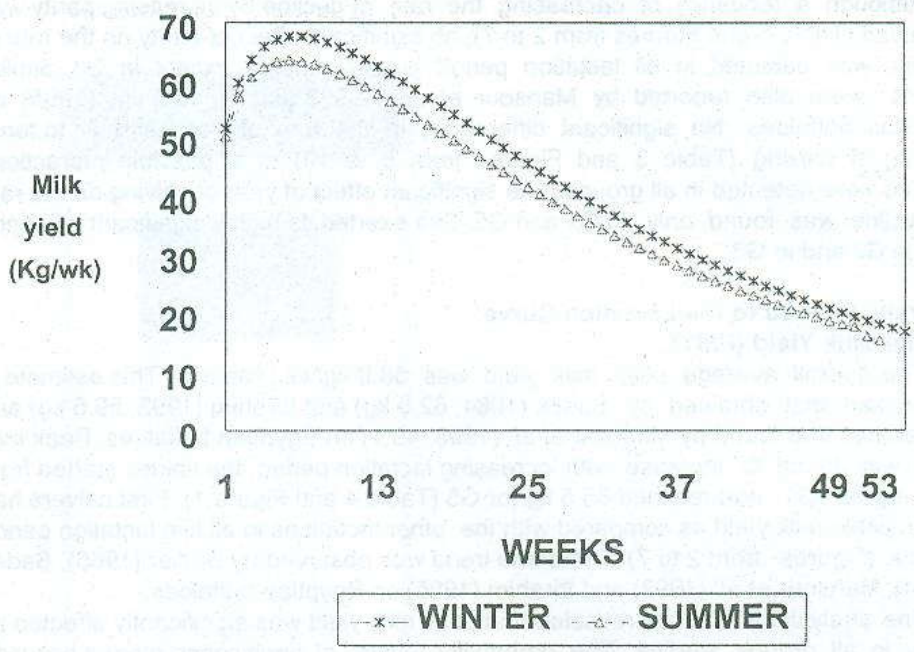

Fig 18.Lactation curve for animals of different seasons dried-off normally at >44 week.(G5)

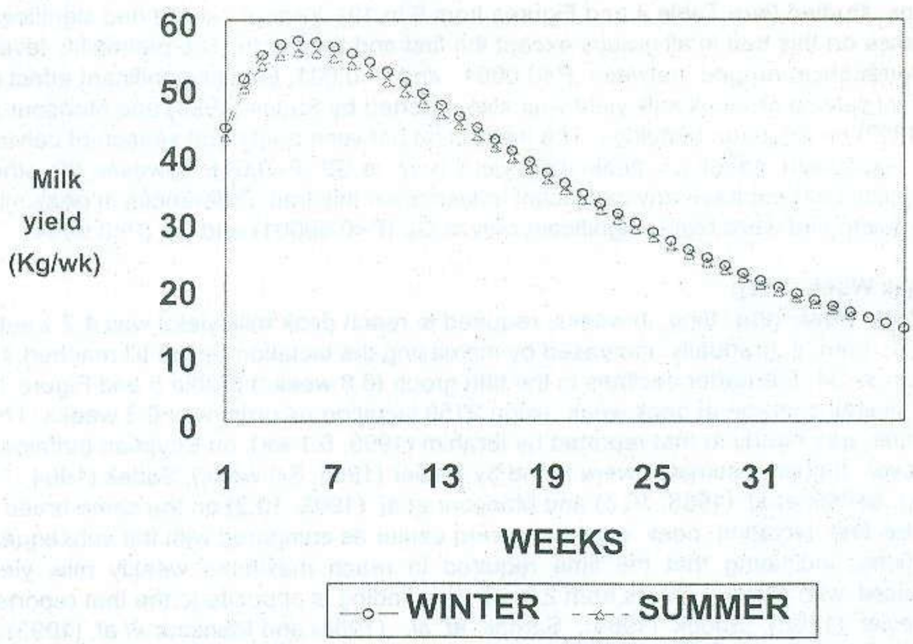

Fig 19. Lactation curve for animals of different seasons

Although a tendency of decreasing the rate of decline by increasing parity was observed (Table 3 and Figures from 2 to 7), no significant effect of parity on the rate of decline was detected in all lactation period groups studied except in G3. Similar results were also reported by Mansour *et al.* (1993) and by Ibrahim (1995) on Egyptian buffaloes. No significant differences in the rate of decline due to farm, season of calving (Table 3 and Figures from 8 to 19) or all possible interactions studied were detected in all groups. The significant effect of year of calving on the rate of decline was found only in G1 and G5. Sire exerted its highly significant influence only in G2 and in G3.

B. Traits Related to the Lactation Curve:

1. Peak Milk Yield (PMY):

The overall average peak milk yield was 58.0 kg/wk (Table 4). This estimate is lower than that obtained by Sadek (1984, 62.8 kg) and Ibrahim (1995, 59.5 kg) and higher than that found by Mansour *et al.* (1993, 45.1) on Egyptian buffaloes. Peak milk yield was found to increase with increasing lactation period, the values started from 47.9 kg for G1 and reached 65.5 kg for G5 (Table 4 and Figure 1). First calvers had lower peak milk yield as compared with the other lactations in all five lactation period groups (Figures from 2 to 7). The same trend was observed by Bedier (1965), Sadek (1984), Mansour *et al.* (1993) and Ibrahim (1995) on Egyptian buffaloes.

The analysis of variance revealed that peak milk yield was significantly affected by parity in all groups studied. The probability levels of significance ranged between $P<0.00001$ and $P<0.0002$. The same results were also observed by Mansour *et al.* (1993) and Ibrahim (1995) in Egyptian buffaloes. However,the effects of farm and season of calving on peak milk yield was not significant in the five lactation period groups studied (see Table 4 and Figures from 8 to 19). Year of calving had significant influence on this trait in all groups except the first and the fourth. The probability levels of significance ranged between $P<0.0001$ and $P<0.001$. Similar significant effect of year of calving on peak milk yield was also reported by Sadek (1984) and Mansour *et al.* (1993) on Egyptian buffaloes. The interaction between parity and season of calving had significant effect on peak milk yield only in G2 ($P<0.01$). However, the other interactions did not have any significant influence on this trait. Differences in peak milk yield due to sire were highly significant only in G2 ($P<0.00001$) and G5 ($P<0.0004$).

2. Peak Week (PW):

Peak week (the time, in weeks, required to reach peak milk yield) was 4.7 weeks for G1, then it gradually increased by increasing the lactation period till reached 7.0 weeks in G4, thereafter declines in the fifth group (6.8 weeks) (Table 5 and Figure 1). The overall average of peak week, using 2158 lactation records, was 6.3 weeks. This estimate was nearly to that reported by Ibrahim (1995, 6.1 wk), on Egyptian buffaloes. However, higher estimates were found by Bedier (1965, 8.6 week), Sadek (1984, 7.7 week), Samak *et al.* (1988, 10.6) and Mansour *et al.* (1993, 10.2) on the same breed.

The first lactation peak week occurred earlier as compared with the subsequent lactations, indicating that the time required to reach maximum weekly milk yield increased with parity (Figures from 2 to 7). This finding is opposite to the that reported of Bedier (1965), Sadek (1984), Samak *et al.* (1988) and Mansour *et al.* (1993) in Egyptian buffaloes, where peak yield of first calvers was attained later as compared with those of the other lactations.

Table 4. Least square means (X±SE) and test of significance of peak milk yield (kg) for different lactation period groups

Classification	G1		G2		G3		G4		G5		All groups	
	N	X ± SE	N	X ± SE	N	X ± SE	N	X ± SE	N	X± SE	N	X ± SE
Overall mean	216	47.9±1.6	293	51.2±2.6	519	55.3± 0.7	511	58.6±0.9	619	65.5±2.0	2158	58.0±0.7
Sire		NS		.00001		NS		NS		.0004		.0002
Parity (p)		.0001		.0002		.0001		.00001		.00001		.00001
1st	66	32.1±3.2	62	42.6±3.4	63	45.3±2.3	61	45.9±2.8	112	55.2±3.2	364	44.0±1.3
2nd	24	47.3±3.9	41	51.3±3.4	71	54.4±1.9	78	50.9±2.3	155	62.1±2.8	369	54.6±1.2
3rd	58	51.0±3.2	74	51.0±3.0	122	57.4±1.4	152	58.9±1.6	200	63.8±.2.5	606	57.9±1.0
4th	13	49.9±4.8	29	58.4±3.5	61	59.7±1.8	57	64.3±2.3	55	78.2±3.2	215	66.0±1.3
5th	17	51.7±4.4	26	53.1±3.8	48	56.8±2.2	43	62.8±2.9	41	63.9±3.6	175	61.6±1.5
>5th	38	55.3±3.9	61	50.1±3.7	154	58.4±2.2	120	68.7±2.7	56	69.9±4.5	429	63.8±1.8
Farm (f)		NS		NS		NS		NS		NS		NS
1	90	50.8±2.2	143	53.5±2.8	298	54.9±1.0	301	57.0±1.3	441	66.6±2.2	1273	58.4±0.8
2	126	45.0±2.2	150	48.7±2.8	221	55.7±1.2	210	60.2±1.5	178	64.4±2.5	885	57.6±0.9
Season of calving(sn)		NS		NS		NS		NS		NS		.04
Winter	116	48.4±2.1	142	50.5±2.7	295	54.4±1.0	297	59.4±1.3	379	67.0±2.1	1229	58.8±0.8
Summer	100	47.4±2.1	151	51.7±2.7	224	56.3±1.0	214	57.8±1.3	240	64.0±2.3	929	57.2±0.8
Year of calving		NS		.0002		.0001		NS		.001		.0001
p x f		NS		NS		NS		NS		NS		NS
p x sn		NS		.01		NS		NS		NS		NS
f x sn		NS		NS		NS		NS		NS		NS

Table 5. Least square means (X ± SE) and test of significance of peak week (in weeks) for different lactation period groups

Classification	G1		G2		G3		G4		G5		All groups	
	N	X ± SE	N	X ± SE	N	X ± SE	N	X ± SE	N	X ± SE	N	X ± SE
Overall mean	216	4.7± 0.1	293	5.3± 0.2	519	5.9± 0.2	511	7.0± 0.2	619	6.8± 0.3	2158	6.3± 0.1
Sire		NS		NS		.03		NS		.0003		.01
Parity (p)		.02		NS		NS		NS		NS		.002
1st	66	3.7± 0.4	62	4.7± 0.5	63	5.8± 0.4	61	6.1± 0.6	112	7.0± 0.5	364	5.5± 0.2
2nd	24	4.1± 0.4	41	4.8± 0.4	71	5.8± 0.3	78	6.9± 0.5	155	6.7± 0.5	369	6.1± 0.2
3rd	58	4.3± 0.4	74	4.8± 0.4	122	5.9± 0.3	152	6.7± 0.4	200	7.6± 0.4	606	6.4± 0.2
4th	13	6.3± 0.5	29	5.9± 0.5	61	5.8± 0.3	57	7.2± 0.5	55	6.0± 0.5	215	6.3± 0.2
5th	17	4.9± 0.5	26	5.7± 0.5	48	5.5± 0.4	43	6.9± 0.6	41	6.7± 0.6	175	6.3± 0.2
>5th	38	4.6± 0.4	61	5.8± 0.5	154	6.7± 0.4	120	8.1± 0.6	56	6.8± 0.8	429	6.9± 0.2
Farm (f)		NS		NS		NS		.01		NS		NS
1	90	4.5± 0.2	143	5.5± 0.3	298	6.1± 0.2	301	6.4± 0.3	441	6.9± 0.4	1273	6.3± 0.1
2	126	4.8± 0.2	150	5.1± 0.3	221	5.7± 0.2	210	7.5± 0.3	178	6.7± 0.4	885	6.2± 0.1
Season of calving(sn)		NS		NS		.04		.05		NS		.02
Winter	116	4.9± 0.2	142	5.2± 0.3	295	5.7± 0.2	297	6.6± 0.3	379	6.6± 0.4	1229	6.1± 0.1
Summer	100	4.5± 0.2	151	5.4± 0.3	224	6.2± 0.2	214	7.3± 0.3	240	7.0± 0.4	929	6.4± 0.1
Year of calving		NS		.01		.02		NS		NS		.0003
p x f		NS		NS		.04		NS		NS		NS
p x sn		NS		.01		NS		NS		NS		NS
f x sn		NS		NS		NS		NS		NS		NS

Parity had significant effect on peak week only in the first group (P<0.02). Difference in peak week between the two farms did not reach the level of significance except in the fourth group (Figures from 8 to 13). Also, season of calving had no significant effect on this trait except in G3 and G4, where summer calvers required longer time to reach peak yield compared to those calving in winter (Figures from 14 to 19).

The effect of year of calving on peak week was not significant in all lactation period groups studied except for G2 and G3. The influence of interaction between parity and farm was not significant on peak week in all groups studied except for G3. However, the effect of the other interactions was insignificant in all lactation period groups studied. The effect of sire on peak week was significant only in G3 (P<0.03) and G5 (P<0.0003).

3. Persistency of Lactation (S):

The overall mean of persistency of lactation for G1 was 29.2%, then it increased gradually by increasing the length of lactation period till reached 79.5% G4 with an overall average of 65.7%, (Table 6). First calvers had lower persistency values as compared with the subsequent lactations except for G5 (see Figures from 2 to 7). The decrease in rate of decline by increasing parity (Table 3) explains the increase of persistency of lactation with advancing parity. Kumar *et al.* (1979) in Indian buffaloes and Ibrahim (1995) on Egyptian buffaloes reported the same trend.

No significant differences among parities, farms, seasons of calving or years of calving were detected in persistency of lactation in all the five lactation period groups studied, except for the effect of year of calving in G5 (Table 6). However, when all records were taken as one group, the effects of the above mentioned factors were significant. Differences in persistency due to all the interactions studied were not significant in all groups except the interaction between parity and farm in G5. The influence of sire on persistency of lactation was highly significant in all lactation period groups studied except the second. The probability levels of significance ranged between P<0.0001 and P<0.05.

C. Total milk yield and lactation period:

1. Total milk yield (TMY):

The overall mean of TMY for G1 was 610 kg, then it gradually increased by increasing the lactation period till 2135 kg for G5 (Table 7). The overall average of the first lactation TMY for all groups together was 1000 kg. Sadek (1984) and Sadek and Ashmawy (1993) on Egyptian buffaloes obtained estimates of 1044 and 1053 kg, respectively, which are almost similar to that found here. The higher values reported by different authors are mainly due to the exclusion of lactations less than 150 days. In this study no animal was discarded because of low milk yield or normal short lactation.

The maximum TMY of all groups together (1695 kg) was attained by the fourth lactation. However, in each lactation period group, the maximum TMY was achieved by the fifth lactation except the first group. The percentages of first lactation TMY to maximum yield were 56%, 65%, 73%, 67% and 78% in the five lactation period groups studied, respectively.

Parity had highly significant effect on TMY for all the lactation period groups. The probability levels of significance ranged between P<0.00001 and P<0.0001. However,

Table 6. Least square means (X ± SE)and test of significance of persistency of lactation (%) for different lactation period groups

Classification	G1		G2		G3		G4		G5		All groups	
	N	X ± SE	N	X ± SE	N	X ± SE	N	X ± SE	N	X ± SE	N	X ± SE
Overall mean	216	29.2± 2.2	293	51.4± 2.5	519	59.4± 3.4	511	79.5± 4.9	619	73.1± 5.2	2158	65.7± 1.4
Sire		.0001		NS		.0005		.0001		.05		NS
Parity (p)		NS		NS		NS		NS		NS		.01
1st	66	23.9± 3.3	62	36.5± 6.4	63	55.3± 7.1	61	68.8± 9.7	112	72.0± 9.7	364	55.4± 3.5
2nd	24	27.5± 3.8	41	45.9± 6.3	71	57.1± 6.0	78	78.6± 8.3	155	65.8± 8.1	369	61.0± 3.1
3rd	58	30.3± 3.2	74	45.2± 4.8	122	69.6± 4.9	152	84.4± 6.3	200	71.3±. 7.1	606	69.0± 2.4
4th	13	33.5± 4.4	29	56.5± 6.7	61	57.3± 5.9	57	71.9± 8.3	55	69.1± 9.7	215	63.9± 3.5
5th	17	28.0± 4.1	26	66.2± 7.8	48	55.0± 6.7	43	83.7± 10.0	41	81.3± 11.3	175	70.8± 4.1
>5th	38	32.0± 3.8	61	57.8± 7.7	154	61.9±6.9	120	89.7± 9.3	56	79.4± 9.3	429	73.8± 4.0
Farm (f)		NS		NS		NS		NS		NS		.03
1	90	30.0± 2.6	143	53.0± 3.5	298	61.6± 4.0	301	75.2± 5.6	441	77.2± 5.9	1273	68.8± 1.9
2	126	28.4± 2.6	150	49.7± 4.0	221	57.1± 4.2	210	83.9± 6.1	178	69.0± 7.1	885	62.6± 2.2
Season of calving(sn)		NS		NS		NS		NS		NS		.04
Winter	116	28.0± 2.6	142	50.5± 3.4	295	57.5± 3.9	297	73.7± 5.5	379	71.1± 5.6	1229	63.2± 1.8
Summer	100	30.3±2.5	151	52.2± 3.4	224	61.2± 3.9	214	85.4± 5.6	240	75.1± 6.4	929	68.1± 1.9
Year of calving		NS		NS		NS		NS		.03		.01
p x f		NS		NS		NS		NS		.01		.02
p x sn		NS		NS		NS		NS		NS		NS
f x sn		NS		NS		NS		NS		NS		NS

Table 7. Least square means (X±SE)and test of significance of total milk yield (kg) for different lactation. period groups

Classification	G1		G2		G3		G4		G5		All groups	
	N	X ± SE	N	X ± SE	N	X ± SE	N	X ± SE	N	X ± SE	N	X ± SE
Overall mean	216	610± 27	293	920± 27	519	1295± 24	511	1680± 29	619	2135± 57	2158	1505± 39
Sire		NS		NS		.01		.002		.00001		.00001
Parity (p)		.0001		.00001		.00001		.0001		.00001		.00001
1st	66	385± 51	62	715± 52	63	1020± 56	61	1265± 63	112	1770± 87	364	1000± 56
2nd	24	635± 60	41	895± 51	71	1250± 47	78	1495± 54	155	2060± 76	369	1445± 52
3rd	58	685± 50	74	890± 41	122	1340± 37	152	1680± 40	200	2225±. 69	606	1540± 46
4th	13	635± 74	29	1010± 54	61	1400± 46	57	1835± 54	55	2275± 87	215	1695± 56
5th	17	615± 68	26	1100± 62	48	1390± 53	43	1895± 65	41	2280± 98	175	1680± 62
>5th	38	690± 61	61	915± 61	154	1370± 54	120	1910± 61	56	2210±120	429	1675± 60
Farm (f)		.01		NS		NS		.0002		NS		.01
1	90	670± 36	143	945± 33	298	1285± 29	301	1595± 35	441	2185± 61	1273	1555± 42
2	126	545± 36	150	895± 35	221	1310± 32	210	1765± 38	178	2090± 69	885	1455± 44
Season of calving(sn)		NS		NS		.005		NS		NS		NS
Winter	116	595± 35	142	895± 32	295	1250± 28	297	1665± 34	379	2175± 61	1229	1530± 42
Summer	100	620±34	151	945± 32	224	1340± 29	214	1690± 34	240	2100± 64	929	1485± 42
Year of calving		NS		.00001		.00001		.0001		.00001		.00001
p x f		NS		NS		NS		.02		NS		NS
p x sn		NS		NS		NS		NS		NS		NS
f x sn		NS		NS		NS		NS		NS		NS

farm had significant effect only on TMY of G1 and G4. Year of calving affected significantly TMY in all lactation period groups studies except the first. The probability levels of significance ranged between P<.00001 and P<.0001.

The influence of season of calving on TMY was insignificant in all lactation groups except the third. Buffaloes of G3 calving in summer produced significantly (P<.005) higher amount of milk (1340±29 kg) than winter calvers (1250±28 kg). The same trend was observed by Mourad (1978) where summer calvers produced 1900±18 kg compared with 1820±17 kg for winter calvers on the same herds. This may be probably due to the system of feeding where, animals were fed only on Egyptian clover during winter season and concentrates and rice straw were only available in summer. It could be seen that summer calvers in G3 produced higher daily milk yiled than winter calvers. This explains the higher TMY in buffales calving in summer compared to winter calvers because they have almost the same lactation period.

The interactions between parity and farm, parity and season of calving and farm and season of calving were insignificant in all groups studied except that between parity and farm for G4.

The influence of sire on TMY was significant in all lactation period groups except for G1 and G2.

2. Lactation period (LP):

The lactation period overall average was 261 days (Table 8). Parity had a significant effect on LP only for G1 and G2, where the first calvers had the shortest lactation period (99 days in G1 and 165 days in G2) and the fourth (128 days in G1) and fifth (183 days in G2) lactations were the longest. The effect of farm was significant only in G3 and G5. Differences in lactation period due to season of calving were highly significant (P<.0000) only for G5. In this group winter calvers had longer LP (383 days) than animals calving in summer (350 days). No significant differences due to year of calving or the interactions were detected in all lactation period groups studied. The effect of sire on LP reached the level of significance only in the last two groups (G4 and G5).

CONCLUSION

In Egyptian buffaloes, the length of lactation period should be considered in describing the shape of lactation curve, since the lactation curve parameters and related traits differed according to the length of lactation. In addition, the higher milk production of buffaloes is mainly due to the intensity of milk production rather than the long lactation period. Different sets of correction factors should be estimated according to the length of lactation period for extension of the incomplete milk records.

REFERENCES

Ali., A. K. A., 1972. Some environmental factors affecting the lactation curve in buffaloes. M. Sc. Thesis, Cairo Univ. Egypt.

Bedier, L. H., 1965. Studies on some productive characteristics of buffaloes in U.A.R. Ph. D. Thesis, Fac. Agric., Ain Shams Univ.

Bhat, P. N. and R. Kumar, 1978. A note on factors affecting the shape of the lactation curve in buffaloes. Indian J. Anim. Sci., 6:608.

Table 8. Least square means (X ± SE) and test of significance of lactation period (day) for different lactation period groups

Classification	G1		G2		G3		G4		G5		All groups	
	N	X ± SE	N	X ± SE	N	X ± SE	N	X ± SE	N	X ± SE	N	X ± SE
Overall mean	216	116± 2.2	293	173±1.3	519	229± 1.1	511	277± 1.3	619	366± 5.9	2158	261± 5.3
Sire		NS		NS		NS		.01		.01		.00001
Parity (p)		.02		.02		NS		NS		NS		.00001
1st	66	99± 5.0	62	165± 3.3	63	228± 2.9	61	279± 3.2	112	383± 10.4	364	231± 7.9
2nd	24	110± 6.1	41	168± 3.2	71	229± 2.4	78	277± 2.6	155	369± 8.8	369	265± 7.3
3rd	58	118± 4.9	74	170± 2.5	122	230± 1.9	152	275± 1.8	200	369±. 7.8	606	262± 6.3
4th	13	128± 7.5	29	179± 3.4	61	227± 2.3	57	276± 2.5	55	364± 10.4	215	272± 7.9
5th	17	115± 6.8	26	183± 4.0	48	228± 2.7	43	276± 3.1	41	356± 12.0	175	267± 8.8
>5th	38	126± 6.2	61	177± 3.9	154	230± 2.8	120	277± 2.9	56	358± 15.0	429	270± 8.6
Farm (f)		NS		NS		.05		NS		.03		.00001
1	90	119± 3.4	143	173± 1.8	298	230± 1.4	301	278± 1.6	441	376± 6.6	1273	273± 5.8
2	126	113± 3.3	150	175± 2.0	221	227± 1.6	210	276± 1.8	178	357± 7.7	885	249± 6.1
Season of calving(sn)		NS		NS		NS		NS		.00001		.0001
Winter	116	116± 3.2	142	174±1.7	295	228± 1.4	297	277± 1.5	379	383± 6.5	1229	270± 5.7
Summer	100	116±3.1	151	174±1.8	224	229± 1.4	214	277± 1.7	240	350± 7.1	929	252± 5.8
Year of calving		NS		NS		NS		NS		NS		NS
p x f		NS		NS		NS		NS		NS		NS
p x sn		NS		NS		NS		NS		NS		NS
f x sn		NS		NS		NS		NS		NS		NS

Cheema, J. S. and S. B. Basu, 1983. Usefulness of some components of the lactation curve for selection in Murrah buffaloes. Anim. Prod., 36:277.

Gondel, K. Z. and P. Rowlinson, 1984. Characterisation of the lactation curve in Pakistani buffaloes. In: British Society of Animal Production Winter Meeting. 26-28 March, paper No. 36,2pp.

Harvey, W. R., 1990. MIXMDEL Mixed Model Least Squares and Maximum Likelihood Computer Program. PC1. Ohio State Univ. Columbia U.S.A (Memeograph).

Ibrahim, M. A.M., 1995. The use of gamma-type function in describing the lactation curve of Egyptian buffaloes. Egypt. J. Anim. Prod. 32:113.

Kumar, R. and P. N. Bhat, 1978. Effect of non-genetic factors on lactation length in Indian buffaloes. Indian J. Anim. Sci., 48:559.

Kumar, R. and P. N. Bhat, 1979. Lactation curve in Indian buffaloes. Indian J. Dairy Sci., 2:156.

Kumar, R., P. N. Bhat, and R. C. Gary, 1979. Persistency of lactation in buffaloes. Indian J. Dairy Sci., 32:318.

Mansour, H., I. A. Soliman, and G. A. Abd El-Hafiz, 1993. Factors affecting lactation curve of buffaloes in Upper Egypt. Proceeding of the International Symposium on: Prospects of Buffalo Production in the Mediterranean and Middle East. Cairo, Egypt 9-12 November, 1992. EAAP Publication No. 62.

Mourad, K.A., 1978. Some productive and reproductive characters of the Egyptian buffaloes. M. Sc. Thesis, Fac. Agric., Cairo Univ.

Ragab, M. T., A. S. Abdel-Aziz, and A. Kamal, 1973. Effect of farm, parity and season of calving on the shape of the lactation curve in buffaloes. Egypt J. Anim. Prod., 13:123.

Sadek, R.R., 1984. Studies on genetic and environmental factors affecting the milk yield production of the Egyptian buffaloes. Ph. D. Thesis, Fac. Agric., Cairo Univ.

Sadek, R. R. and A. A., Ashmawy,1993. Expected genetic improvement of milk yield of Egyptian buffaloes. Proceeding of the International Symposium on: Prospects of Buffalo Production in the Mediterranean and Middle East. Cairo, Egypt 9-12 November, 1992. EAAP Publication No. 62.

Samak, M. A., G. A. Hassan, A. Hassan, and N. Yassen, 1988. The lacattion curve and performance of the Egyptian buffalo. Alex. Sci. Exch., 9:83.

Soliman, A.M.A., 1976. The genetics of the lactation curve. M. Sc. Thesis, Ain Shams Univ., Cairo, Egypt.

Wood, P. D. P., 1967. Algebric model of the lactation curve in cattle. Nature, 216:164.

Wood, P. D.P., 1979. A simple model of lactation curve for milk yield, food requirement and body weight. Anim. Prod., 28:55-63.

Yadev, M.C., B.C. Katpatal, and S.N. Kauskik, 1977. Components of inverse polynomial function of lactation curve and factors affecting them in Hariana and its Friesian crosses. Indian J. Anim. Sci., 47:77

تقدير مقاييس منحنى الحليب فى الجاموس المصرى

ربيع رجب صادق[1] ، محاسن معوض محمد[2] ، محمد عبد العزيز إبراهيم[1] ، هدى محمد عبد الرؤوف عبد اللطيف[2]

١- قسم الإنتاج الحيوانى ، كلية الزراعة ، جامعة القاهرة ، ٢- معهد بحوث الإنتاج الحيوانى، القاهرة، مصر

أستخدم فى هذه الدراسة ٢١٥٨ سجلاً لإنتاج اللبن تمثل ستة مواسم حليب جمعت خلال ١٦ عاماً من مزرعتين على ٣٦٤ حيواناً. قُسمت السجلات إلى خمس مجموعات تبعاً لطول موسم الحليب، تبدأ من ١٢ أسبوعاً وتنتهى عند ٤٤ أسبوعاً حليب فأكثر بفترة طولها ٨ أسابيع بين كل مجموعتين. وكان الهدف من الدراسة هو إستخدام دالة-جاما فى حساب مقاييس منحنى الحليب ووصف شكله فى الجاموس المصرى تبعاً لإختلاف طول موسم الحليب.

وأوضحت النتائج أن متوسط إنتاج اللبن الأولى يزداد بزيادة طول موسم الحليب ، كان معدل زيادة إنتاج اللبن حتى أقصى إنتاج أسرع فى الحيوانات قصيرة موسم الحليب مقارنة بطويلة الموسم ، بينما إنخفض معدل النقص فى إنتاج اللبن بعد أقصىإنتاج بزيادة طول فترة الحليب.

زادت المثابرة على إنتاج اللبن بزيادة طول موسم الحليب ، حيث كانت ٢٩,٢٪ للحيوانات التى حلبت ١٢-٢٠ أسبوعاً بينما بلغت ٧٩,٥٪ للحيوانات التى حلبت ٤٤ أسبوعاً بمتوسط عام ٦٥,٧٪. تحقق أقصى إنتاج أسبوعى من اللبن (٤٧,٩ كجم) عند ٤,٧ أسبوع فى الحيوانات التى حلبت ١٢-٢٠ أسبوعاً ، بينما حققت الحيوانات طويلة الموسم إنتاجها من اللبن (٦٥,٥ كجم) بعد ٧ أسابيع من بدء الموسم فى المتوسط. كان المتوسط العام لإنتاج اللبن الكلى وطول موسم الحليب في جميع المجاميع التى درست ١٥٠٥ كجم ، ٢٦١ يوم على الترتيب.