



Identified factors influencing the occurrence of abnormal lactation curves in Iranian buffaloes

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ABSTRACT

Atypical lactation curves (ALCs), mostly characterized by the lack of any distinguished peak, are the subject of this study. Logistic regression was used to assess the influences of some non-genetic factors on the occurrence of ALCs in Iranian buffaloes. The data set consisted of 24,679 lactation records from 11,478 buffaloes that calved during the years 1996 to 2012. As a reasonable statistical criterion, odds and odds ratio were used to evaluate the probable differences between the various levels of the factors. Genetic analysis of the ALC trait was also carried out using Bayesian approach to estimate heritability and repeatability parameters. The results revealed that almost 44% of the lactation curves were atypical. All factors but ecotype factor had significant effects on the occurrence of ALCs. The frequency of ALCs increased until the third parity and decreased afterward, therefore the highest and the lowest values of the trait were observed in the third and 10th parities, respectively. Unlike the parity effect, ageing of the buffaloes caused the odds values to be continually increasing. The incidence of the ALCs for buffaloes calved out of season (July to December) was more likely (almost 15%) than those calved in season (January to June). The structure of the data also affected the trait significantly, such that the lactations with 4 recorded test-days were 1.75 times more likely to have atypical curves than those with 8 recorded test-days. Heritability and repeatability of the occurrence of ALCs were estimated very low and were 0.020 and 0.036, respectively.

Key words: Atypical curves, Bayesian approach, Buffalo, Threshold trait, Logistic regression

There are about 630,000 buffaloes in Iran with ranking of 16 among 43 countries in the world (Food and Agriculture Organization of the United Nations 2009). This population consists of three ecotypes namely Azeri (about 80% in the northwest), Khuzestani (18.8% in the southwest) and Shomali (less than 3% in the north of country). Iranian buffalo population is spread in a vast range of environmental conditions from hot and humid (Khuzestan), cold and semi dry (Azeri), and humid (Shomali) climates (Shokrollahi *et al.* 2009). Furthermore, it has outstanding features such as high percentage of milk fat, high resistance to diseases, long economic life, optimal use of low quality foods and producing milk suitable for making special products such as Mozzarella cheese. Rearing practices in Iran is under the rural system and in open areas. Depending on financial status of farmers, buffaloes are kept in small herds and, in some cases, the herd size is less than 10. Buffaloes are primarily reared for milk production while meat and other

products are considered as by-products. For example, about 40% of dairy products of Khuzestan province are from the buffaloes (Taheri-Dezfuli *et al.* 2011). The total milk yield in 240, 270, or 305 days bases is often being used in genetic evaluation of buffaloes (Tonhati *et al.* 2007, Zullo *et al.* 2007). This criterion is also being used for culling buffalo cows and making management decisions. Test-day and peak yield records are sometimes recommended to be used for early culling of cows with low milk yield. It is also commented that in buffalo, as well as in dairy cattle, peak yield has the most effective influence on lactation curve shape and the total milk yield (Farhangfar and Naeemipour 2007). High peak yields in normal lactation curves are correlated with high total milk yield (Gengler 1996). An ideal lactation curve has a high peak yield with moderate persistency. However, some curves do not have distinguished peak. Furthermore, another proportion of the curves are concave in shape. These curves, characterized by the absence of the lactation peak, are called atypical curves. The frequency of atypical curves in dairy cattle is 20–30% of total lactation curves (Dimauro *et al.* 2005, Macciotta *et al.* 2005, Rekik and Ben Gara 2004). Some of mathematical functions such as Wood's Incomplete Gama and Wilmlink have an advantage of distinguishing atypical

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lactation curves (ALCs) from the typical ones (Dimauro *et al.* 2005, Shokrollahi and Hasanpur 2014). Thereby to detect and distinguish the normal shapes from the atypical ones, one of these functions should be used. Besides the random effect of genetic potential of buffaloes, there are several known and unknown non-genetic factors that influence the shape of lactation curves. In the current study, effect of some non-genetic factors affecting the possible occurrence of ALC shapes as well as estimation of heritability and repeatability values on ALC trait are discussed.

MATERIALS AND METHODS

The data set consisted of 24,679 lactations of 11,478 buffaloes. Data were collected by the Iranian Animal Breeding Center from buffaloes that calved during years 1996 to 2012. Only lactations having at least 4 test-day records were included. The incomplete gamma function was used to characterize the shape of the lactation curves of the buffalo cows individually. Fitting curves was carried out using Gauss–Newton algorithm in NLIN procedure of SAS software. The equation of incomplete gamma functions is as follows:

$$Y_t = at^be^{-ct}$$

where Y_t is the observed milk yield at day t of lactation period, a is a parameter associated with yield at the beginning of lactation (initial milk yield), b is a parameter associated with the ascending phase before peak yield (inclining slope of lactation curve), and c is a parameter associated with the decreasing phase after peak yield (declining slope of lactation curve). As described in Table 1, the fitted curves were classified as standard and atypical on the basis of different combination of signs for parameters b and c (Jeretina *et al.* 2013).

Logistic regression model (logistic procedure in SAS) was used to evaluate the effects of some independent factors on the probability of occurrence of ALCs. When binomial variable whose outcome is 1 if the lactation curve is atypical and 0 otherwise is considered, the link function of logit could be used to link the probability of having an atypical curve to the various explanatory factors. The link function of logit is as follow;

$$\text{Logit}(p_i) = \text{Log} \left(\frac{p}{1-p} \right) = b_0 + \sum_{i=1}^n b_i X_i$$

Where p is the expected value of the probability of having an ALC (probability of success), $1-p$ is the probability of failure, b_0 is the intercept, b_i is the regression coefficients for the i^{th} explanatory variable X and n is the number of variables. Explanatory variables which were ecotype (Khuzestani and Azeri), year of birth (1984 to 2011), year of calving (1996 to 2012), age classes at calving (age<60, 60<age<84, 84<age<108, 108<age<132, and age>132 Months), season of calving as in season (January to June) and out of season (July to December), village (107 levels), number of test days recorded per lactation (4, 5, 6, 7 and 8), and parity (1 to 10; parities higher than 10 are considered as 10th parity) were converted to regression variables of 1

Table 1. Signs of incomplete gamma function parameters in creating typical and atypical curve shapes

Curve parameters*		Curve shape	Curve type
b	C		
+	+	Standard curve	Typical
-	+	Continually decreasing	Atypical
+	-	Continually increasing	
-	-	Reverse curve	

* The parameter “a” is always greater than 0.

or 0. For example in season class was given the value 0 if out of season, class was assigned 1. The Odds statistic was used as a way to assess the probability of ALC occurrence. In the simplest form, the odds of an event (atypical curve in here) happening is the probability that the event will happen divided by the probability that the event will not happen. If the odds are greater than 1 then the occurrence of ALCs is more likely than normal lactation curves. If the odds are less than 1 then the occurrence of ALCs is less likely than normal lactation curves. If the chance of happening the event equals to the chance of the event not happening, then the odds value will equal to 1. Logistic regression model is expressed as a ratio of two Odds Ratio (OR). The OR ranges between 0 and infinity. An OR>1 indicates that the probability of observing an ALC in a given level of a factor is greater than the probability of observing similar curves in the highest level of the same factor.

Since the trait is threshold in nature with discrete distribution (atypical or normal), the Gibbs1F90 program (Misztal *et al.* 2002) was used to estimate the genetic parameters of the trait. In addition to the fixed effects, which have mentioned previously, random variables of additive genetic and permanent environment effects were also included in a univariate repeatability model. To accomplish this, a total of 2949, 1349, and 765 records from the first, second, and third lactation were used, respectively.

The gibbs1F90 program works under Bayesian approach and Gibbs sampling algorithm to analyze categorical traits. The Gibbs sampler was run for 100,000 rounds, and the first 10,000 rounds were discarded as a warming-up period. A thinning interval of 10 rounds was used to retain sampled values that reduced lag correlation among thinned samples. The posterior means of variance components were calculated using Postgibbs program, and those expected values for heritability and repeatability of the ALC trait calculated afterward.

RESULTS AND DISCUSSION

After fitting the lactation curves, only 13,457 lactations out of 24,679 lactations had normal curve shape (54.5%), whereas the remaining lactation curves were atypical (45.5%). This is higher than those reported for Italian buffaloes (Dimauro *et al.* 2005) and for some dairy cattle breeds (Macciotta *et al.* 2005, Rekik and Ben Gara 2004). Except for ecotype factor, all of the other factors which included in the logistic regression model had significant

effect on the occurrence of ALCs. Jeretina *et al.* (2013) reported that the occurrence of ALCs varies extremely from herd to herd, season to season, parity to parity, and etc. They showed that this type of curves is more frequent in the state and cooperative herds than in herds of farmers or groups of investors. The shape of lactation curves is reported to be depends on physiological condition of animals, too. Angeles-Hernandez *et al.* (2013) in a study on lactation curves of dairy sheep showed that the shape of lactation curve depends on season of lambing, type of lambing and number of lambing.

Estimates of logistic regression coefficients (β_s), odds ($\exp(\beta_i)$) and odds ratios of atypical lactations in various levels of ecotype, parity, calving age classes, season of calving, and number of recorded test-days per lactation are given in table 2. Odds ratio is the ratio of a given level's odds value of a factor and the highest level's odds value of the same factor. The odds value of intercept which is $\exp(-0.813)=0.44$ refers to the frequency of buffaloes that have ALC for all explanatory variables at their highest levels,

Table 2. Estimates of logistic regression coefficients and odds ratio

Parameter	β_s	S.E.	Odds**	OR	WCL***	
Intercept*	-0.813	6.87	0.44			
Khuzestani	-0.350	0.12	0.97	0.94	0.58	1.50
Azeri			1.03			
Parity 1	0.081	0.06	1.08	1.46	1.15	1.75
2	0.139	0.05	1.15	1.55	1.25	1.85
3	0.164	0.04	1.18	1.59	1.29	1.88
4	0.131	0.04	1.14	1.54	1.26	1.81
5	0.018	0.04	1.02	1.37	1.13	1.61
6	-0.007	0.04	0.99	1.34	1.11	1.56
7	-0.034	0.05	0.97	1.30	1.08	1.52
8	-0.060	0.06	0.94	1.27	1.05	1.49
9	-0.131	0.07	0.88	1.18	0.97	1.40
10			0.77			
Age <60 (month)	-0.044	0.06	0.96	0.78	0.60	0.94
60<Age<84	-0.132	0.04	0.88	0.71	0.58	0.83
84<Age<108	-0.044	0.03	0.96	0.78	0.66	0.88
108<Age<132	0.012	0.04	1.01	0.82	0.72	0.91
Age>132			1.28			
Out season	-0.082	0.02	0.92	0.85	0.78	0.92
calving						
In season			1.09			
calving						
N of test days 4	0.314	0.03	1.37	1.75	1.60	1.91
per lactation						
5	0.046	0.03	1.05	1.34	1.22	1.45
6	-0.018	0.03	0.98	1.25	1.15	1.36
7	-0.098	0.03	0.91	1.16	1.06	1.25
8			0.78			

The intercept value corresponds to the log odds of having an atypical lactation curve for all explanatory variables at their highest levels, i.e. a buffalo calving in 1387, at an age class >132 month, calved in season, and etc.** Odds= $\exp(\beta_i)$; *** 95 % Wald confidence limit (WCL). If the confidence limit of odds ratio does not include an odds ratio of one, then the odds of two levels differs significantly $P<0.05$.

e.g. a buffalo that calved in year 2012, at age class>132 months, calved in season, and etc.

Estimated odds ratio for Khuzestani ecotype was 0.94 which means that the probability of occurrence of ALCs in Azeri ecotype was 6% more than in Khuzestani ecotype. However, this difference was not statistically significant ($P=>0.05$), because the corresponding Wald confident limits of odds ratio includes value 1.

The odds ratios of the various levels of parity to the tenth level increased significantly ($P<0.05$) until parity 3 and decreased afterward. It means that the highest and the lowest amount of the ALC observed in the 3rd and 10th parities, respectively. Rekik and Ben Gara (2004) reported that the value of odds for the second parity was 1.2 times higher than the first parity in Holstein cattle. They mentioned that the reasons of higher ALCs in the second parity, compared to the first parity, was not clear.

Despite the parity effect, the ORs of the age classes at calving were not decreasing with ageing. This means that the highest frequency of ALCs have occurred in older ages (age>132 months) but the lowest frequency were for buffaloes in the second age class (60<age<84 months).

Season of calving showed strange results, such that the probability of occurrence of ALCs of buffaloes having calved out of season were slightly, but significantly, ($p<0.05$) lower than the buffaloes having calved at in season class. The calving frequency of the buffaloes in the out of season class is lower than in in season class, especially in Khuzestani ecotype (687 vs. 7546). It seems that the lower amount of labour of recording due to the lower amount of information needed to be collected, made the recording process straightforward from the buffaloes having calved out of season. Therefore the frequency of partial recorded lactations in out of season class seems to be low. As it will be shown later, the frequency of atypical curves for lactations with no missing test-day record was very lower than those with imperfect lactations. Generally there is no identified reason for the higher ALCs frequency in some seasons but frequent changes in quantity and quality of ration as well as physiological and health problems related to harsh environmental conditions are possibly lead to this type of lactation curves (Rekik and Ben Gara 2004). Intrinsic restrictions or shortage of food in some seasons and limited amount of supplemented foods for non-industrial animals means that the animals, especially dairy ones, could not express their potential merits in some periods of times and, thereby, have affected shape of lactation (Angeles-Hernandez *et al.* 2013). These researcher showed that ewes having lambd in autumn had normal but those having lambd in other seasons had atypical curve shapes.

Incomplete lactation records, also, caused the ALCs frequency to be high, so that the frequency of these curves for lactations with 4, 5, 6, and 7 recorded test-days were 1.75, 1.36, 1.25, and 1.16 times of those lactations with 8 test-day records, respectively. Due to the shorter lactation length and lower number of monthly collected records per

Table 3. Variance components, heritability and repeatability estimates of atypical lactation curves

Va (S.E.)	Vpe (S.E.)	Ve (S.E.)	Vp	Heritability	Repeatability
0.021 (0.022)	0.017 (0.016)	1.021 (0.029)	1.059	0.020	0.036

Va, Vpe, Ve, and Vp are additive, permanent environment, residual, and phenotypic variances, respectively.

lactation in buffaloes compared to dairy cattle, missing of any test-day records exerts greater errors and biases in lactation curve fitting. Therefore, improvement of buffalo recording system as well as enhancement the quality and quantity of the test-day records collecting process could be useful to solve this problem. Jeretina *et al.* (2013) mentioned that one of the most probable reasons for the occurrence of ALCs is attributed to non-efficiency of milk recording scheme. Macciotta *et al.* (2005) reported that besides the environmental factors, the structure of the data also had significant effect on the shape of Italian buffaloes lactation curves. They showed that the buffaloes with first recorded test-day before 25 days of lactation had more chance to have normal lactation records than those with the first test-day records after 25 days of lactation. Silvestre *et al.* (2006) reported that accuracy of some mathematical models was affected tremendously by increasing the interval between tests and the interval between calving and the first test-day recording. Moreover, Rekik and Ben Gara (2004) showed that the probability of occurrence of ALCs increases by 4% for each day that the first test-day date is delayed. These conclusions showed that data collection, especially during the initial phase of lactation and before the peak yield is crucial for correct estimation of lactation curve shape (Boujenane 2013).

It is worth mentioned that the function, in itself, can alter the frequency of ALCs. For example (Angeles-Hernandez *et al.* 2013) reported that due to the negligible dependence between the first and second parameters of Wilmink function (a and b parameters), the number of ALCs detected by this model is less than other functions. The correlation between parameters of Wood's Incomplete Gamma function, however, is substantially high and this can lead to higher number of curves to be fit abnormally. These researchers mentioned that the flexibility of the function is very important in estimating the parameters and shape of the curves accurately.

The results of genetic analysis of the trait are reported in Table 3. The results revealed that both of heritability and repeatability parameters were very low, concluding very low similarity of the relatives and also that only a few genetic changes would be possible with genetic selection of the animals based on having typical lactation curves to reduce ALCs. Also, culling of buffaloes with abnormal curves based on early lactations may not reduce the frequency of these curves in subsequent parities. The high and significant influences of non-genetic factors on the trait, as observed above, confirms this idea. However, a typical curves are reported to be related to low genetic merit of animals (Angeles-Hernandez *et al.* 2013). It is postulated

that animals with lower potential for milk yield would be prone to have an ALCs (Angeles-Hernandez *et al.* 2013).

In conclusion, the effects of environmental factors on the shape of lactation curves were considerably high and they contributed to much of the phenotypic variation of the trait, while additive genetic and permanent environmental components of the phenotypic variance were negligible and caused the heritability and repeatability parameters to be very low.

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REFERENCES

- Angeles-Hernandez J C, Albarran-Portillo B, Gomez Gonzalez A V, Pescador Salas N and Gonzalez-Ronquillo M. 2013. Comparison of mathematical models applied to F1 dairy sheep lactations in organic farm and environmental factors affecting lactation curve parameter. *Asian-Australasian Journal of Animal Science* **26** (8): 1119–26.
- Boujenane I. 2013. Comparison of different lactation curve models to describe lactation curve in Moroccan Holstein Friesian dairy cows. *Iranian Journal of Applied Animal Science* **3** (4): 817–82.
- Dimauro C, Catillo G, Bacciue N and Mcciotta N P P. 2005. Fit of different linear models to the lactation curve of Italian water buffalo. Italian. *Italian Journal of Animal Science* **4**: 22–24.
- Farhangfar H and Naeemipour H. 2007. Phenotypic study of lactation curve in Iranian Holsteins. *Journal of Agricultural Science and Technology* **9**: 279–86.
- Jeretina J, Babnik D and Škorjanc D. 2013. Modeling lactation curve standards for test-day milk yield in Holeystein, Brown Swiss and Semmental cows. *Journal of Animal and Plant Sciences* **23** (3): 754–62.
- Macciotta N P, Vicario D and Cappio-Borlino A. 2005. Detection of different shapes of lactation curve for milk yield in dairy cattle by empirical mathematical models. *Journal of Dairy Science* **88** (3): 1178–91.
- Rekik B and Ben Gara A. 2004. Factors affecting the occurrence of atypical lactations for Holstein–Friesian cows. *Livestock Production Science* **87**: 240–45.
- Shokrollahi B, Amirinia C, Djadid N D, Amirmozaffari N and Kamali M A. 2009. Development of polymorphic microsatellite loci for Iranian river buffalo (*Bubalus bubalis*). *African Journal of Biotechnology* **8** (24): 6750–55.
- Shokrollahi B and Hasanpur K. 2014. Study of individual lactation patterns of Iranian dairy buffaloes. *Journal of Agriculture and Rural Development in the Tropics and Subtropics* **115** (2): 125–33.

- Silvestre A M, Petim-Batista F and Colaco J. 2006. The accuracy of seven mathematical functions in modeling dairy cattle lactation curves based on test-day records from varying sample schemes. *Journal of Dairy Science* **89** (5): 1813–21.
- Taheri-Dezfuli B, Nejati-Javaremi A, Abbasi M A, Fayazi J and Chamani M. 2011. Economic weights of milk production traits for buffalo herds in the southwest of Iran using profit equation. *World Applied Science Journal* **15**: 1604–13.
- Tonhati H, Baldi F S, M laureano M M and Albuquerque L G. 2007. Genetic parameters for milk yield of *Bubalus bubalis* using unadjusted and adjusted milk production for days in milk. *Italian Journal of Animal Science* **6**: 310–13.
- Zullo A, Barone C M A, Zicarelli L and Matassino D. 2007. An application of the integrative method for extending part lactation milk record in Mediterranean Italian buffalo reared in Caserta province. *Italian Journal of Animal Science* **6**: 417–20.