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Extension model of lactation curves to evaluate the effect of the recombinant bovine somatotropin on milk yield in Holstein cows

[*Modelo de extensão de curvas de lactação para avaliar o efeito da somatotropina bovina recombinante sobre a produção de leite em vacas Holstein*]

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ABSTRACT

An extension model of lactation curves was used to determine the effect of recombinant bovine somatotropin (bST-r) on milk yield in Holstein dairy cattle. This model use the fitted values obtained by the Wood model, and was tested on the records of 66 cows. The milk yield predicted with the extension model and the observed yield were compared and no significant differences were observed (P>0.05). Once the extension model was validated, the milk yield tests of 199 cows were used. The cows received bST-r 500mg by subcutaneous injections. The injections were applied after 100 days in milk at 14-day intervals (seven injections). The observed milk yield was compared with the yield expected by the extension model. An increase of 5.3% was observed in milk yield in response to the bST-r. This increase is lower than that reported in the literature in response to the growth hormone in dairy cattle. It is concluded that extension model used in the present work is reliable for extending the lactation curve in Holstein cows, and the increase in milk yield in response to the application of bST-r, determined in the same animal using the extension model, was lower than that reported by other authors.

Keywords: dairy cattle, bST-r, mathematical model

RESUMO

Um modelo de extensão de curvas de lactância foi utilizado para determinar o efeito da somatotropina bovina recombinante (bST-r) sobre a produção de leite em vacas Holstein. Este modelo, que utiliza os valores ajustados obtidos pelo modelo de Wood, foi testato nos registros de 66 vacas. A produção de leite predita com o modelo de extensão e a produção observada foram comparadas e não se observaram diferenças significativas (P>0,05). Uma vez validado o modelo de extensão, utilizaram-se os controles de produção de leite (de cada 15 dias) de 199 vacas. As vacas receberam injeções de 500mg de bST-r via subcutânea. As injeções fora aplicadas a partir dos 100 dias de lactação a intervalos de 14 dias (sete injeções). A produção de leite observada foi comparada com a produção esperada com o modelo de extensão. Observou-se um incremento de 5,3% na produção de leite em resposta à bST-r. Este incremento foi menor que o relatado na literatura em resposta ao hormônio do crescimento em vacas leiteiras. O modelo de extensão usado é confiável para estender a curva de lactação na vaca Holstein, e o aumento do rendimento de leite em resposta à aplicação de bST-r, determinado no mesmo animal usando o modelo de extensão, foi inferior ao observado por outros autores.

Palavras-chave: vaca leiteira, bST-r, modelo matemático

INTRODUCTION

The interest for bovine somatotropin (bST) began when Asdell (1932) demonstrated a response in the milk yield of dairy goats treated with raw extract of pituitary gland. Shortly afterwards, the response to the raw extract of pituitary gland was examined in 2,000 cows, in

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which a single injection induced a temporary increase of milk yield (Azimov and Krouze, 1937).

The action mechanism of the bST-r in dairy cows has been explained by a homeorretic effect which modifies the partitioning nutrients for milk synthesis (Velez and Donkin, 2004).

The increase of milk yield in response to the bST-r has been observed in all the breeds of dairy cows, in animals of different parity and genetic potential (Etherton and Bauman, 1998). This increase has varied from 10 to 28% (Stehr et al., 2001). In these investigations, comparisons have been made of cows treated with bST-r with untreated cows and, based on the average milk yield of both groups, the difference has been established, and thus the potential of bST-r to increase milk yield. However, although in these studies contemporary groups of cows were formed, there exists the inconvenience that the impact of the bST-r on the milk yield is not measured in the own cow, but in a group of contemporary different cows, so there may be a bias.

The incomplete Gamma function proposed by Wood (Wood, 1967) has been the most widely used model to describe the lactation curve in dairy cattle (Groenewald and Viljoen, 2003; Muniz et al., 2007). This model has been successfully used to predict incomplete lactations in cows and goats (Leitch and Burnside, 1986).

Based on the fore mentioned, the objective of the present study was to evaluate the effect of the recombinant bovine somatotropin on milk yield in Holstein dairy cows using an extension model of the lactation curve.

MATERIAL AND METHODS

The study was carried out in a dairy herd located in Vizcaíno, B.C.S., at geographical coordinates 27º 31' 30" N and 113ºº 20' 20" W, at 600 masl. The climate is BWhs(x') semidry (Carta…, 1994), with mean annual rainfall of 91.9mm. The mean annual temperature is 21.3ºC, with maximum 40.1ºC in summer (Cartas…, 1982).

To validate the fit of the lactation curve with the Wood model (Wood, 1967), the milk yield tests of 66 Holstein cows (21, 27, and 18 cows of first, second, and third calving, respectively) were used. The cows had free access to total mixed rations. The TMR was composed of forage, grains, some additives such as rumen bypass fat, and rumen buffers. The cows were milked twice milking and their milk yield tests were used to fit the lactation curve using the Wood model and the IML procedure SAS/1998. The mathematical model was used as follows:

$y_n = An^B e^{(-Cn)}$, in which:

y_n is the milk yield (kg) on the day n.

n are the days in milk.

e is the base of the natural logarithm.

A is the ascendant factor associated with the average milk yield per day.

B is the factor related to the curvature prior to the lactation peak.

C is the factor related to the curvature after the lactation peak.

The goodness of fit the model was determined by the value of the determination coefficient, the variation coefficient, and an analysis of residuals.

Once proven the goodness of fit the Wood model, the first four milk yield tests of each cow were taken (every 15 days). From these milk yield tests, the lactation curve was extended (up to test number 12) using the model proposed by Alenda (1998):

$Yn = Pn + \beta1\ (M305 - P305) + \beta2\ (Yucc - Pucc)$, in which:

Yn is the yield predicted on day n.

Pn is the milk yield estimated by the fitted lactation curve on day n, in the group of contemporaries (lactation number- year of calving- calving season) to which the cow belongs.

β1 is a parameter to be estimated using the method of least squares.

β2 is a parameter to be estimated using the method of least squares.

M305 is the average milk yield at 305 days in milk in the group of contemporary cows.

P305 is the average milk yield at 305 days, estimated from the fit of the lactation curve for the group of contemporaries to which the cow belongs.

Yucc is the milk yield in the last known test (four milk yield tests).

Pucc is the milk yield on the same day of the test (in the fourth record), estimated with the fitted lactation curve using the Wood model.

To validate the extension model of the lactation curves, the averages of milk yield were compared from the fourth to the twelfth tests resulting from the extension model (period on average coincides with the implementation of the bST-r), with the real milk yield observed in each cow. For this purpose, a t test was used for paired samples (Daniel, 2004).

To determine the effect of the bST-r on milk yield, the semi-monthly milk yield tests (12 tests) were used from each one of 199 cows grouped according to the lactation number (one, two, and three or more lactations), year of calving (2005 and 2006), and calving season (winter, spring, summer, and fall). The cows were subcutaneously injected with 500mg of bST-r (Lactotropin; Monsanto – México) in the fossa iliaca. Each cow received seven injections. The injections were applied after 100 days in milk, at 14-day intervals each one. The conditions for being included in the experiment were health, body condition score equal or higher than 3 (Wildman et al., 1982), and pregnancy.

The milk yield was registered every 15 days from the onset of lactation until milk yield test number twelve. Then, the first four milk yield tests of each cow were taken and from that moment the lactation curve was extended (until the twelfth milk yield test) using the previously described extension model. Using a t test for paired samples (SAS/1998), a comparison was made of the real milk yield of the cows injected with bST-r and the milk yield estimated with the extension model. The difference between them was attributed to the effect of the bST-r.

RESULTS AND DISCUSSION

The Wood model adequately fit the milk yield curve of first, second, and third lactation cows (Fig. 1, 2, and 3, respectively).

These results agree with those obtained by other investigators using the same model (Ramírez et al., 1998; Muñiz et al., 2007; Quintero et al., 2007).

The determination coefficients (r^2) for all of the lactations were 0.99 and the variation coefficients were 2.52, 7.24, and 12.6% for the first, second and third lactations, respectively.

The differences between the means of the milk yield resulting from the extension model and the real milk yield observed in each cow are shown in Tab. 1. It is observed that there was no difference between the observed values and the values predicted by the model ($P>0.05$). This indicates that the model may be reliable for predicting milk yield. Consequently, it may be reliable for estimating what would have been the milk yield if the hormone had not been injected.

The milk yield predicted with the Wood model fitted to 305 days was 10,052.75±326.7kg, while the milk yield in response to the application of bST-r fitted to 305 days was 10,591.5 ± 291.3kg. This difference represents an increase in the total milk yield of 5.3% per cow. Although this result is within the range of increase expected in response to the bST-r in this region where heat stress is high, it is lower than those reported by other authors: Cervantes and Vejar (1997) reported 8.3% of increase when they injected the bST-r to Holstein cows in intermediate stages of lactation under severe heat stress; while Collier et al. (2001) found an increase of 9.1% and Stehr et al. (2001) observed 27% of increase. However, it should be considered that the percentage of increase estimated in the present work was made on the same cow injected with bST-r; whereas in the studies carried out by the other investigators, the increase was estimated by comparing the milk yield obtained in control animals with those of animals treated with bST-r. Thus, it could suggest that, in these studies, the increase in milk yield in response to the bST-r was overestimated.

The milk yield predicted by the extension model and that observed in response to the bST-r according to the calving season are shown in Tab. 2.

It can be observed that the percentage of increase in milk yield in each season varied from 3 to 7.3%. The highest increase was recorded in the fall and the lowest in the summer. The fore cited is consistent, given that the effects of heat stress on milk yield in dairy cattle are well known (West, 2003; Botero and Vertel, 2006).

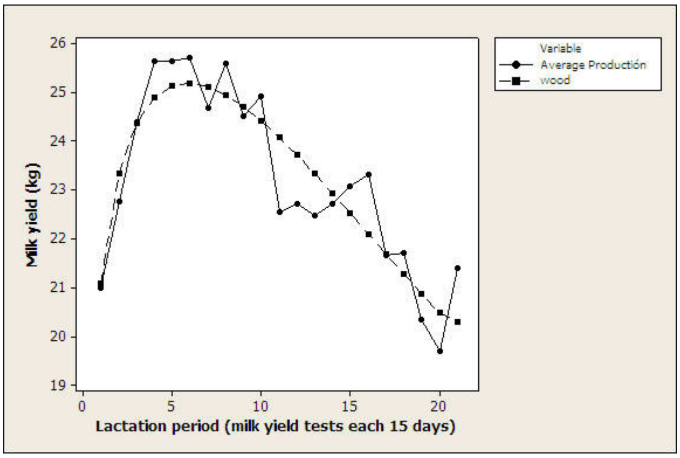

Figure 1. Real and fitted milk yield according to the Wood model in first calving, Holstein cows.

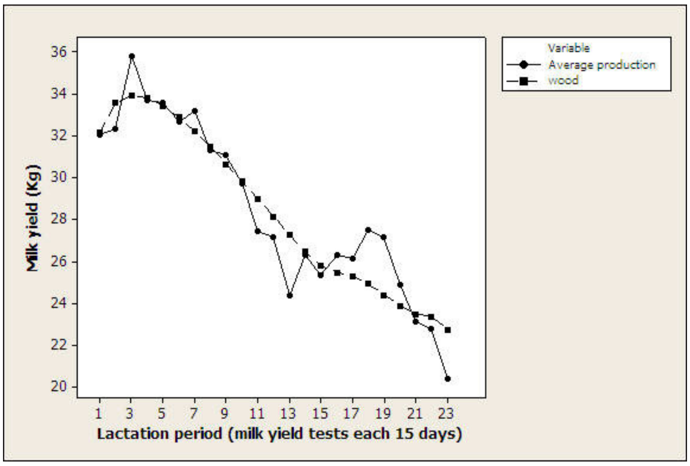

Figure 2. Real and fitted milk yield according to the Wood model in second calving, Holstein cows.

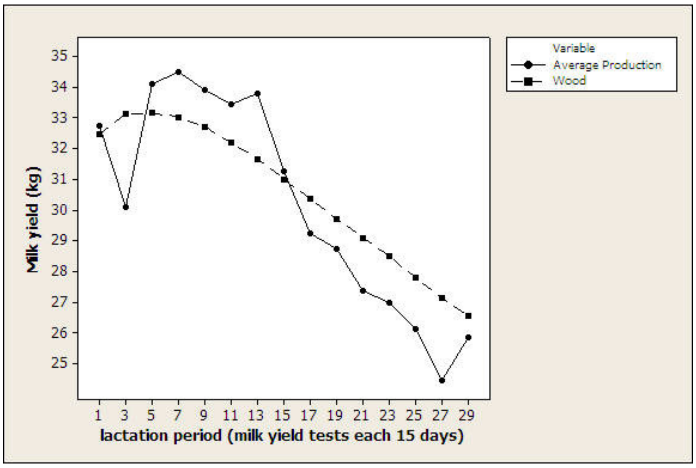

Figure 3. Real and fitted milk yield according to the Wood model in third calving, Holstein cows.

Table 1. Differences among the means of the milk yield resulting from the extension model, and the real milk yield observed in each Holstein cow from the fourth to twelfth milk yield tests at 15-day intervals

Lactation[1]	n[2]	Difference (kg)	S.E.[3]	P>t
1	21	0.283	0.45	0.54
2	27	-0.399	0.60	0.51
3	18	-0.481	1.19	0.75

[1]lactation number; [2]animals; [3]standard error.

Table 2. Estimated and observed milk yield in Holstein cows, according to the calving season

Calving season	Milk yield (kg)		Difference	
	Estimated	Observed	kg	%
Winter	10,248	10,813	564.8	5.5
Spring	10,130	10,689	559.5	5.5
Summer	9,835	10,130	295.7	3.0
Autum	9,998	10,734	736.8	7.3

Data from Fig. 4 represent the average increase expected in milk yield in response to the application of the bST-r. The area existing between the line corresponding to the estimated yield and the line that represents the observed yield graphically indicate the effect of bST-r on the milk yield.

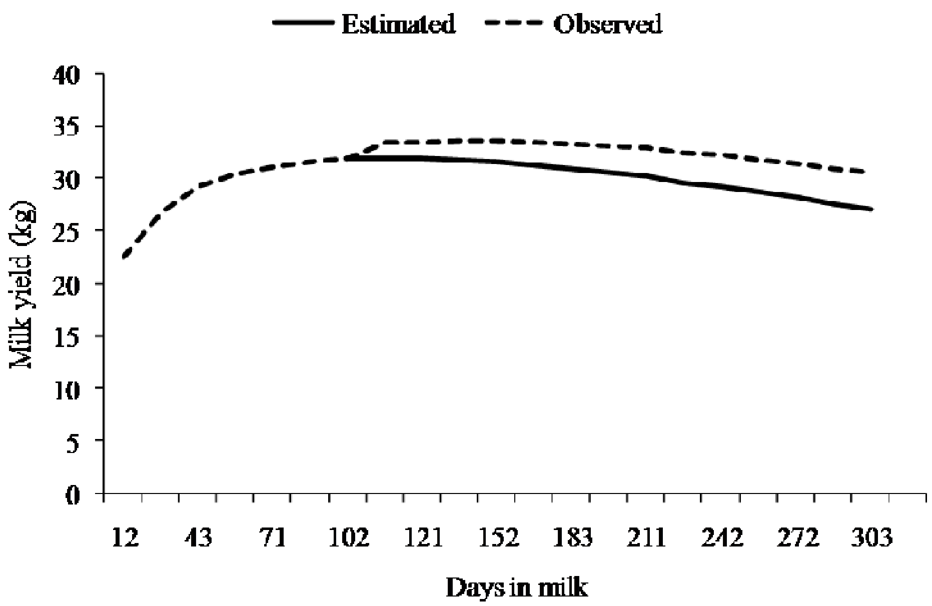

Figure 4. Observed and estimated lactation curves in Holstein cows that received a protocol with injections of recombinant bovine somatotropin.

CONCLUSIONS

The extension model used in the present work is reliable for extending the lactation curve in Holstein cows. The increase in milk yield in response to the application of bST-r, determined in the same animal using the extension model, was lower than those reported by other authors.

REFERENCES

ALENDA, R. Control productivo y morfológico. En: MEMORIAS DEL VIII CURSO INTERNACIONAL SOBRE MEJORA GENÉTICA ANIMAL, 1998, Madrid: INIA, 1998. p.35-54.

ASDELL, S.A. The effect of the injection of hypophyseal extract in advanced lactation. *Am. J. Physiol.*, v.100, p.137-140, 1932.

ASIMOV, G.J.; KROUZE, N.K. The lactogenic preparations from the anterior pituitary and the increase in milk yield from cows. *J. Dairy Sci.*, v.20, p.289-306, 1937.

BOTERO, L.; VERTEL, M. Modelo matemático aplicado a la curva de lactancia en ganado vacuno de doble propósito. *Rev. Med. Vet. Zootec.*, v.11, p.759-765, 2006.

CARTA estatal de climas: Síntesis geográfica del estado de Baja California Sur. México: INEGI, 1994.

CARTAS geográficas del Estado de Baja California Sur. México, DF: DGTENAL, SPP, 1982.

CERVANTES, M.R.; VEJAR, L.R. Producción de leche de vacas Holstein inyectadas con somatotropina bovina (bST) en estrés calórico severo. *Agrociencia*, v.31, p.241-245, 1997.

COLLIER, R.J.; BYATT, J.C.; DENHAM, S.C. et al. Effects of sustained release bovine somatotropin (sometribove) on animal health in commercial dairy herds. *J. Dairy Sci.*, v.84, p.1098-1108, 2001.

DANIEL, W.W. *Bioestadistica*: *Base para el análisis de las ciencias de la salud.* 4.ed. México: LIMUSA, p.241-249, 2004.

ETHERTON, T.D.; BAUMAN, D.E. Biology of somatotropin in growth and lactation of domestic animals. *Physiol. Rev.*, v.78, p.745-761, 1998.

GROENEWALD, P.C.N.; VILJOEN, C.S. A Bayesian model for analysis of lactation curves of dairy goats. *J. Agric. Biol. Environ. Sta.*, v.8, p.75-83, 2003.

LEITCH, H.W.; BURNSIDE, E.B. Bovine somatotropin: Boon for the 1990's. *Holstein Journal*, 1986. Available on: http://cgil.uoguelph.ca/pub/articles/bovine.html. Accessed on: July 28, 2008.

MUÑIZ, J.A.; FONSECA, F.; PAIVA, M.H. et al. Evaluation of lactation curve of low-yielding Gyr cows: a Bayesian approach. *Acta Sci. Anim. Sci.*, v.29, p.79-83, 2007.

QUINTERO, J.C.; SERNA, J.I.; HURTADO, N.A. Modelos matemáticos para curvas de lactancia en ganado lechero. *Rev. Col. Cienc. Pec.*, v.20, p.149-156, 2007.

RAMÍREZ, V.R.; RAMÍREZ, G.; NÚÑEZ, R. Curvas de lactancia en vacas Angus, Suizo Pardo y sus cruzas: II Comparación de ecuaciones. *Agrociencia*, v.32, p.325-330, 1998.

STEHR, W.; TWELE, B.; ROSALES, L. Uso de somatotrofina recombinante en vacas lecheras. *Arch. Zootec.*, v.50, p.419-422, 2001.

VELEZ, J.C.; DONKIN, S.S. Bovine somatotropin increases hepatic phosphoenolpyruvate carboxykinase mRNA in lactating dairy cows. *J. Dairy Sci.*, v.87, p.1325-1335, 2004.

WEST, J.W. Effects of heat-stress on production in dairy cattle. *J. Dairy Sci.*, v.86, p.2131-2144, 2003.

WILDMAN, E.E.; JONES, G.M.; WAGNER, P.E. et al. A dairy cow body condition scoring system and its relationship to selected production characteristics. *J. Dairy. Sci.*, v.65, p.495-501, 1982.

WOOD, P.D.P. Algebraic model of the lactation curve in cattle. *Nature*, v.216, p.164, 1967.