ISSN - 2277 - 2755

Journal of Agricultural Science and Environment

ESTIMATION OF OPTIMAL DOSE OF BOVINE SOMATOTROPIN FOR MAXIMUM MILK YIELD RESPONSE IN WEST AFRICAN DWARF GOATS

I.J. JAMES[1*], O.A OSINOWO[1], O.F. SMITH[1], M.N. BEMJI[2] AND P.I. REKWOT[3]

[1]Department of Animal Physiology, [2]Department of Animal Breeding and Genetics, University of Agriculture, Abeokuta, Nigeria. [3]National Animal Production Research Institute, Shika, Ahmadu Bello University, Zaria, Nigeria.

***Corresponding author:** james_ikej@yahoo.com **Tel:** +234 8060672833

ABSTRACT

Optimal dose of bovine somatotropin (bST) in a sustained-delivery vehicle required for maximum milk yield response was estimated in twenty-four lactating West African Dwarf (WAD) goats in three 14-day periods using quadratic equation. The goats were divided equally into four treatment groups, each comprising six does. The first group (control, T_0) received no bST while the other groups received bST (T_1, 20 mg; T_2, 40 mg; T_3, 60 mg) injected at 2-week intervals commencing from the 7th week postpartum for 6 weeks. Does were milked twice daily (7:30 am and 7:30 pm) and milk yield recorded daily. Daily milk yield response (DMY) to bST was significantly ($p<0.001$) influenced by bST dose, day from bST treatment and parity during the 2nd period of bST treatment but only bST dose and parity significantly influenced ($p<0.001$) DMY during the 1st and 3rd periods of bST treatment. The mean relative response of DMY of bST-treated goats exceeded the control by 48 – 78 % in the entire periods of bST administration. Highest predicted response of 80.5 % in the 3rd period and lowest response of 66.2 % in the 1st period of bST treatment (when compared to the control) were observed, thus indicating that bST positively affected the shape of the lactation curve for possible higher yield in extended lactation. Although, the trend of observed and predicted optimal doses of bST needed for maximum DMY were well-fitted by the Quadratic equation during the three periods of bST treatment, it varied inconsistently with periods of bST treatment (stages of lactation). Therefore, the uniform optimal dose of 50.71 mg per 2 weeks estimated by quadratic equations; $Y = 141.318 + 4.097X – 0.041X^2$, $R^2 = 99.90$), $Y = 100.912 + 2.926X – 0.030X^2$, $R^2 = 99.49$ and $Y = 5935.420 + 172.071X – 1.735X^2$, $R^2 = 99.49$ and needed for maximum DMY of 242.86 ml, relative DMY of 74 % and cumulative milk yield response of 10214.29 ml respectively over the entire periods could be adopted in West African Dwarf goats in order to reduce the complexity of differential injections administered with respect to stages of lactation.

Key words: WAD goats, milk yield, bovine somatotropin.

INTRODUCTION

Somatotropin, also known as growth hormone, is a protein hormone of about 190 amino acids that is synthesized and secreted by cells called somatotrophs in the anterior pituitary (Hafez *et al.,* 2000), it controls several complex physiological processes, including growth, metabolism, milk synthesis and secretion. It is established that administration of bovine somatotropin (bST) enhances milk production in dairy ruminants including goats (Baldi *et al.,* 2002; Boutinaud *et al.,* 2003). Administration of a slow-release formulation of bST to dairy ruminants improves persistency of lactation by slowing down the rate of post-peak decline (Gallo *et al.,* 1997; Chiofallo *et al.,* 1999), changing the shape of lactation curve (Gallo *et al.,* 1997; James, 2009), indicating opportunity for extended lactation (Bauman and Vernon, 1993; Etherton and Bauman, 1998) and thus indicating increased total milk yield (Annen *et al.,* 2004). Studies have indicated that bST was administered to dairy ruminants for milk yield boost as a single bolus, a constant infusion, or as equal episodic pulses at 4-hr intervals (Bauman and McCutcheon, 1986). Typically, bST has been administered by daily injection. However, several sustained- release formulations have been developed in which a small volume is injected at intervals ranging from 2 to 4 weeks (Chilliard, 1989; Hartnell *et al.,* 1991; McGuffey *et al.,* 1991) and from 7 to 8 weeks (Gallo *et al.,* 1997; Chadio *et al.,* 2000). Regardless, the types of bST, mode and form of administration, different doses with different milk yield responses have been reported in dairy cows (Etherton and Bauman, 1998). Information about the use of bST in dairy goats is much scarcer. Treatment of temperate dairy goats with bST resulted in increased milk yield (Baldi *et al.,* 2002; James, 2009) but the galactopoeitic response to the exogenous hormone is more variable and less intense than that observed for dairy cows (Garsen *et al.,* 1989). These observations are much more intense with tropical West African Dwarf (WAD) goats which have not been selected for dairying. Milk yield responses of 48 – 78 % to doses of 20 – 60 mg bST per 2weeks of administration to WAD goats have been reported by James (2009). However, lactational response to exogenous bST is a function of daily dose represented by a hyperbolic (Bauman and McCutcheon, 1986) or quadratic (James, 2009) dose response curve with a pattern of diminishing marginal returns to increasing bST dose (McGuffey *et al.,* 1991). The daily dose needed to optimize milk yield response has been reported to result in blood concentrations of bST that are within the range typically observed during episodic release of endogenous hormone but average daily concentrations are several-folds higher than before treatment. In view of the facts that the use of bST to increase milk yield in WAD goats is limited, low selection intensity of WAD goats for dairying and no recommended dose of bST for WAD goats in Nigeria, therefore the study was aimed at estimating optimal dose of bST needed to elicit maximum milk yield response in West African Dwarf goats of Nigeria.

MATERIALS AND METHODS

Description of the experimental site

The experiment was conducted at the Goat Unit of the Teaching and Research Farm of the College of Animal Science and Livestock Production, University of Agriculture, Abeokuta. Abeokuta falls within the Rain Forest Vegetation zone of South-Western Nigeria at latitude 7°13' 49.46"N, longitude 3°26' 11.98"E (Google Earth, 2006) and altitude of 76 meters above sea level. The climate is humid with a mean annual rainfall of 1037 mm. The annual mean temperature and humidity are 34.7°C and 82% respectively.

Experimental animals and their management

Twenty-four West African Dwarf lactating does of first and second parities with ages between 1.5 and 3 years and whose weights ranged from 11 – 16 kg were selected from the existing flock on the farm and used for the experiment. The goats were housed in cross-ventilated pens with slated floors and water given *ad libitum.* The goats were under intensive management system with zero grazing ('cut and feed') and 0.3 – 0.5 kg/head/day concentrate feed supplement, consisting of about 17% crude protein, 11.56% crude fibre, 4.68% ether extract and 2076.70 kcal/kg metabolisable energy was fed to the animals. *Panicum maximum* grass was chopped and 1.0 kg/head/day fed to the goats. The proximate composition of the grass was of 5.37, 33.35, 66.31, 42.79 and 19.71% of crude protein, crude fibre, neutral detergent fibre and acid detergent fibre respectively.

Experimental procedure

Twenty-four lactating does were divided equally into four treatment groups, each group comprising of six does with first and second parity evenly distributed as well as liveweight equalization among treatment groups. The first group, which was the control (T_0) received no bovine somatotropin injection while the remaining three groups received bovine somatotropin injections at different doses: 20 mg (T_1), 40 mg (T_2) and 60 mg (T_3). The bovine somatotropin, Lactotropina ^{MR}, division Sanidad Animal, Eli Lilly CO., Mexico is in a sustained-release formulation for 14 days interval.

The injections of bovine somatotropin were done at the left and right scapular regions (Davis *et al.,* 1999) alternately every 14 days commencing from 7th to 11th week of lactation after a 2-week adjustment period with a total of 3 injections per doe in 3 periods of bST treatment: 1st period (7 – 8 weeks), 2nd period (9 – 10 weeks) and 3rd period (11 – 12 weeks). The doses of bST were selected based on the preliminary results obtained by Rekwot (personal communication) on the study on milk yield and composition of Red Sokoto goats treated with bovine somatotropin at the National Animal Production Research Institute (NAPRI), Nigeria. The study on the effect of recombinant bovine somatotropin (rbST) administration on milk production, composition and some haemato-biochemical parameters of lactating goats in Egypt, by Sallam *et al.* (2005) also provided the basis for the selection of the doses.

Data collection

The West African Dwarf does were milked twice daily at 7:30 a.m. and 7:30 p.m. The a.m. and p.m. yields were added to determine the daily milk yield (DMY). The does were milked for 42 days commencing from the 7th to the 12th week of lactation. The milk yield was measured by a measuring cylinder and recorded.

Statistical analysis

Data generated on DMY of does for each period of bST treatment were subjected to analysis of variance (ANOVA) in 4 × 14 × 2 factorial design with 6 replicates using the Systat Analytical Computer Package, version 5.02 (SYSTAT, 1992). The statistical model used was:

$$Y_{ijkl} = \mu + A_i + B_j + C_k + A{*}B_{ij} + A{*}C_{ik} + \varepsilon_{ijkl} \quad \text{......equation 1}$$

where Y_{ijkl} = Trait of interest

A_i = Fixed effect of ith bST dose (i = 0, 20, 40 & 60 mg)

B_j = Fixed effect of jth day from bST treatment (j = day 1 – day 14)

C_k	=	Fixed effect of k^{th} parity (k = 1st & 2nd)
$A*B_{ij}$	=	The interaction between i^{th} bST dose and j^{th} day from bST treatment
$A*C_{ik}$	=	The interaction between i^{th} bST dose and k^{th} parity of does
ε_{ijkl}	=	Random error associated with each record.

Data generated on cumulative milk yield of does over entire period of bST treatment were subjected to analysis of variance (ANOVA) in 4 × 2 factorial design with 6 replicates using the Systat Analytical Computer Package, version 5.02 (SYSTAT, 1992). The statistical model used was:

$$Y_{ijk} = \mu + A_i + B_j + A*B_{ij} + \varepsilon_{ijk} \quad \text{......equation 2}$$

where

Y_{ijk}	=	Trait of interest
A_i	=	Fixed effect of i^{th} bST dose (i = 0, 20, 40 & 60 mg)
B_j	=	Fixed effect of k^{th} parity (k = 1st & 2nd)
$A*B_{ij}$	=	The interaction between i^{th} bST dose and j^{th} parity of does
ε_{ijk}	=	Random error associated with each record.

Estimation of optimal dose of bST for maximum milk yield response

The relative response of DMY of does was computed by converting the least squares means generated from the ANOVA into percentages with 100 % as the minimum benchmark. The estimation of optimal dose of bST for maximum DMY response, relative DMY response and cumulative milk yield response in WAD does were carried out by graphical representations of dose-response curves. Regressing DMY response over bST doses during each period of bST treatment and entire period of bST treatment using quadratic equation carried this out. The regressions were carried out using non-linear regression package (SYSTAT, 1992) for the generation of lactation curve parameters needed for the estimation.

RESULTS AND DISCUSSION

The summary of least squares analysis of variance on the effects of bST dose, day from treatment and parity on DMY response of WAD does during each period of bST treatment is presented in Table 1. Average DMY response of WAD does was significantly ($p<0.001$) influenced by bST dose, day from bST treatment and parity during the 2nd period of bST treatment but only bST dose and parity significantly influenced ($p<0.001$) DMY response during the 1st and 3rd periods of bST treatment. In the 1st period, average DMY of WAD does increased with increasing bST doses with mean values of 149.84, 221.17, 236.16 and 254.89 ml for T_0, T_1, T_2 and T_3 respectively. The relative response of DMY of WAD does in T_1, T_2 and T_3 exceeded T_0 by 47.60, 57.61 and 70.10 % respectively.

The average DMY of WAD does increased significantly ($p<0.001$) with increasing parity. In the 2nd period, average DMY of WAD does increased with increasing bST doses with mean values of 140.41, 218.01, 239.61 and 232.57 ml for T_0, T_1, T_2 and T_3 respectively.

Table 1: Summary of least squares analysis of variance showing the effects of bovine somatotropin (bST) dose, day from treatment and parity on daily milk yield response of West African Dwarf goats during periods of bST treatment

Source of variation	DF	Mean-Square		
		Daily milk yield		
		Period in lactation		
		1st period (7 – 8th week)	2nd period (9 – 10th week)	3rd period (11 – 12th week)
bST dose (D)	3	177029.51***	175602.12***	190685.31***
Day from bST treatment (T)	13	2012.52	4051.36**	3549.19
Parity (P)	1	248221.894***	287849.38***	197904.38***
D × T	39	401.77	417.30	709.61
D × P	3	4831.66	5928.47*	13978.94***
Error	276	3046.01	1731.90	2182.61

*p<0.05, **p<0.01 and ***p<0.001

Relative response of daily milk yield of WAD does in T_1, T_2 and T_3 exceeded T_0 by 55.27, 70.65 and 65.65 % respectively.

The average DMY of WAD does increased significantly ($p<0.001$) with increasing parity. There was significant ($p<0.05$) interaction between bST dose and parity. Second parity does consistently had higher DMY even with the same bST dose. In the 3rd period, average daily milk yield of WAD does increased with increasing bST doses with mean values of 129.88, 192.52, 230.02 and 30.62 ml for T_0, T_1, T_2 and T_3 respectively. Relative response of DMY of WAD does in T_1, T_2 and T_3 exceeded T_0 by 48.23, 77.10 and 78.33 % respectively. There was significant ($p<0.01$) interaction between bST dose and parity. Second parity does consistently had higher daily milk yield even with the same dose. This observation shows the strong galactopoietic capacity of bST in enhancing milk yield and it corroborates the pattern of milk yield of crossbred Alpine goats administered bST at three periods lasting 28 days each as reported by Chadio *et al.* (2000), even though a higher response of DMY to bST treatment was observed in this study. Baldi *et al.* (2002) and Boutinaud *et al.* (2003) using a higher dose in Alpine goats, also observed a lower response in DMY, although in these studies treatment with bST commenced at the 26th and the 32nd weeks of lactation respectively. The disparity to a

Table 2: Summary of least squares analysis of variance showing the effects of bovine somatotropin (bST) dose and parity on cumulative milk yield response of West African Dwarf goats during lactation

Source of variation	DF	Mean square
		Cumulative milk yield
bST dose (D)	3	22.45E+06**
Parity (P)	1	30.65E+06**
D × P	3	77.39E+04
Error	16	35.02E+05

**p<0.01

in WAD does appears to be 50.71 mg (Figures 4). Generally, the optimal dose that elicited maximum milk yield in WAD does varied inconsistently with period of bST treatment (stages of lactation). This is because state and activity of mammary tissue differ with stage of lactation. Mammary cell proliferation occurs rapidly in early lactation but reduces with late lactation (Dijkstra *et al.,* 1997). Therefore, in order to reduce the complexity of differential injections administered with respect to stages of lactation, the uniform optimal dose of 50.71 mg estimated for the entire stages of lactation could be adopted. The dose stated is close to 50.50 mg per 2 weeks observed by Rekwot (personal communication) in his preliminary findings on Red Sokoto goats in National Animal Production Research Institute of Nigeria. He reported the superiority of 50.50 mg bST as against 35.70 mg bST in eliciting higher milk yield response in Red Sokoto goats, even though, the lower dose produced milk yield at par with the higher dose towards the end of treatment period. Etherton and Bauman (1998) reported that the daily dose needed to optimize milk yield response results in blood concentrations of bST that are within the range typically observed during episodic release of endogenous hormone. Highest predicted response of 80.5% in the 3rd period and lowest response of 66.2% in the 1st period of bST treatment (when compared to the control) observed (Figures 1 – 3), indicated that bST positively affected the shape of the lactation curve. Gallo *et al.* (1997) considered that this response was a medium term effect of bST, which improve lactation persistency and increase cumulative milk yield. It can be hypothesized that bST could increase total milk yield of WAD does in an extended lactation since similar observation has been made on Saanen does in 180 days in milk (Baldi *et al.* 2002) and Red Sokoto does in 98 days in milk (Rekwot, personal communication). Therefore, possible commercial use would be over the last two thirds or three fourths of the lactation cycle (Bauman and Vernon, 1993.

greater extent could be attributed mainly to the differences in the breeds of animal used and to a lesser extent to doses of bST administered, stages of lactation when bST was administered, protocols for bST administration and formulations of bST used. The authors used temperate breeds of goats that have long been selected for dairying but in this study, we used a tropical breed; West African Dwarf goats which has not under gone the same extensive selection for dairy purpose. Thus, it is expected that WAD goats should exhibit greater response in DMY to bST treatment. More so, administration of bST to lactating goats has also increased milk production by 50 – 60 % (James *et al.,* 1996). The observation that the 2nd parity does had higher daily milk yield (DMY) than the 1st parity does could be attributed to larger udder size with larger population of milk secreting cells (alveoli) available for higher milk synthesis and secretion. Since udder size is positively correlated with milk yield (James, 2000). Bemji *et al.* (2007) made similar observations in WAD and Red Sokoto goats in Nigeria.

The summary of least squares analysis of variance on the effects of bST dose and parity on cumulative milk yield response of WAD does during entire period of bST treatment is presented in Table 2. Cumulative milk yield response of WAD does during the entire period of bST treatment was significantly ($p<0.01$) influenced by bST dose and parity. Cumulative milk yield of WAD does increased correspondingly with increasing bST doses with mean values of 5881.75, 8843.83, 9881.17 and 10067.17 ml for T_0, T_1, T_2 and T_3 respectively. Relative cumulative milk yield response to bST treatment of WAD does in T_1, T_2 and T_3 exceeded T_0 by 50.36, 68.00 and 71.16 % respectively. Cumulative milk yield increased with increasing parity but there was no significant ($p>0.05$) interaction between bST dose and parity. Similar explanations given for the observations made on DMY response to bST treatment, may also hold for the observation made on cumulative milk yield response to bST-treated WAD does.

The trends of the observed and predicted optimal bST dose for maximum milk yield in WAD does during each period of bST treatment were well-fitted in quadratic equations, meaning that the response of DMY to bST treatment follows quadratic pattern and this was shown by their high R^2 values (Figures 1 – 4). This observation agrees with the report of McGuffey *et al.* (1991) who stated that lactational response to bST is a function of the daily dose represented by a hyperbolic dose-response curve with a pattern of diminishing returns to increasing bST dose. In the 1st period of bST treatment (7 – 8 week), the optimal dose that elicited maximum milk yield of 253.71 ml and relative milk yield response of 166.20% in WAD does was 54.81 g (Figures 1). In the 2nd period of bST treatment (9 – 10 week), the optimal dose that elicited maximum milk yield of 245.71 ml and relative milk yield response of 174.00% in WAD does was 45.19 mg (Figures 2). In the 3rd period of bST treatment (11 – 12 week), the optimal dose that elicited maximum milk yield of 234.86 ml and relative milk yield response of 180.50% in WAD does was 52.59 mg (Figures 3). The trends of the observed and predicted optimal bST dose for average, relative and maximum milk yield of WAD during entire periods of bST treatment were well-fitted in quadratic equations. The optimal dose that elicited maximum average milk yield of 242.86 ml, relative milk yield response of 174.00% and cumulative milk yield response of 10214.29 ml

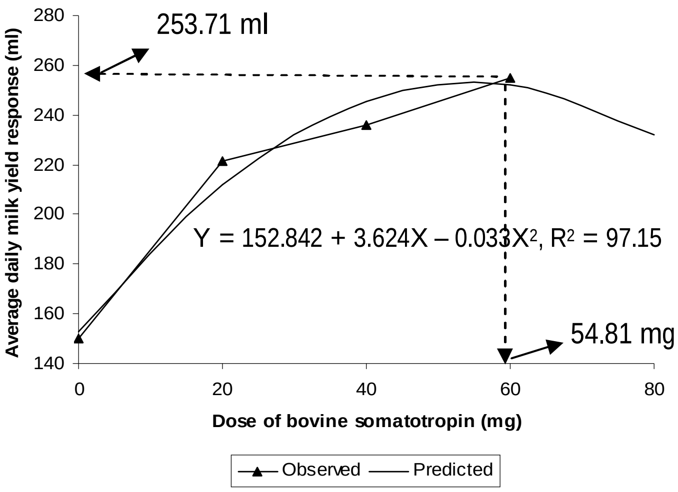

Figure 1a: Observed and predicted optimal dose of bST for maximum daily milk yield response in goats

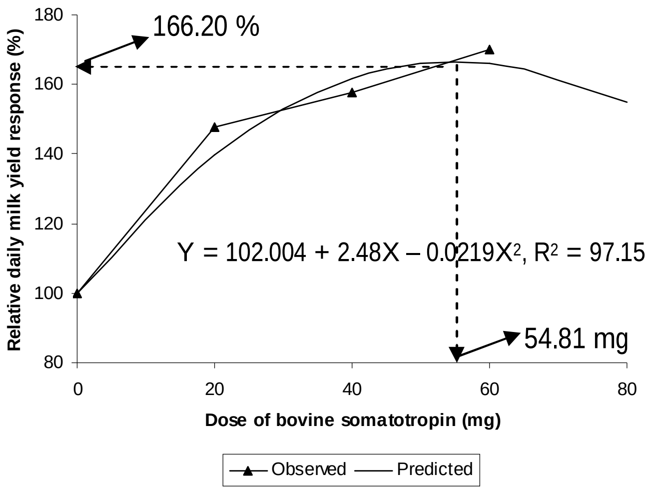

Figure 1b: Observed and predicted optimal dose of bST for maximum relative daily milk yield response in goats

Figure 1: Observed and predicted optimal dose of bST for maximum milk yield response during 1st period (7th – 8th week of lactation) of bST treatment in West African Dwarf goats

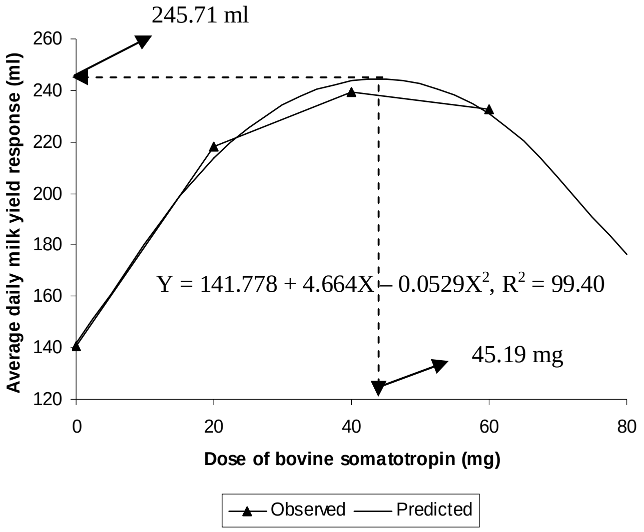

Figure 2a: Observed and predicted optimal dose of bST for maximum daily milk yield response in goats

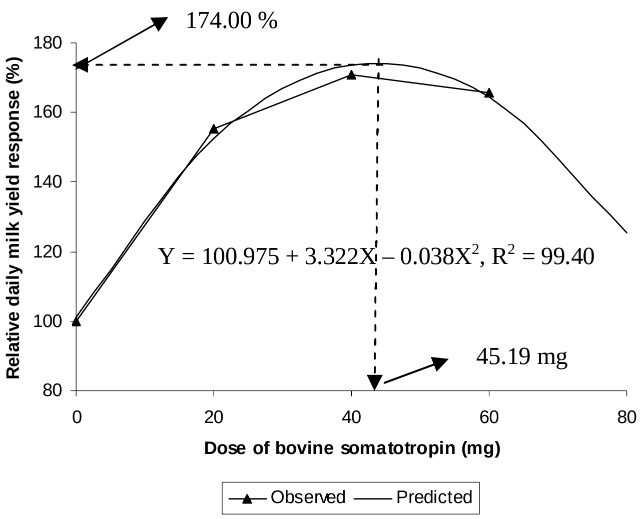

Figure 2b:Observed and predicted optimal dose of bST for maximum relative daily milk yield response in goats

Figure 2: Observed and predicted optimal dose of bST for maximum milk yield response during 2nd period (9th – 10th week of lactation) of bST treatment in West African Dwarf goats.

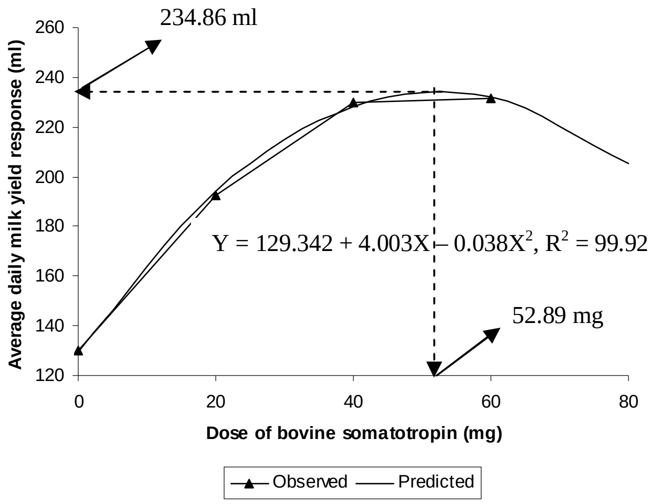

Figure 3a:Observed and predicted optimal dose of bST for maximum daily milk yield response in goats

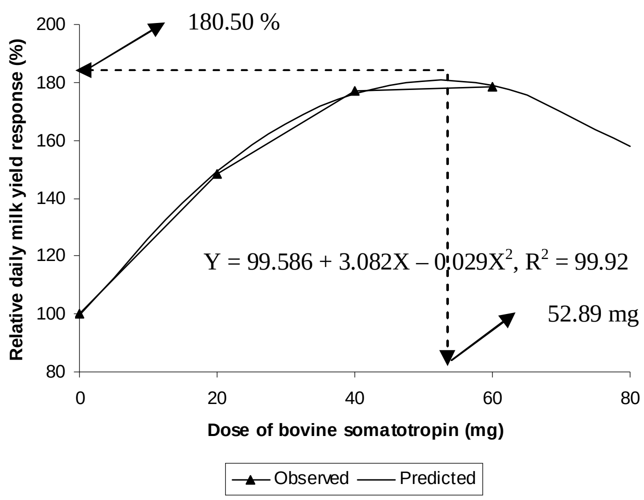

Figure 3b:Observed and predicted optimal dose of bST for maximum relative daily milk yield response in goats

Figure 3:Observed and predicted optimal dose of bST for maximum milk yield response during 3rd period (11th – 12th week of lactation) of bST treatment in West African Dwarf goats

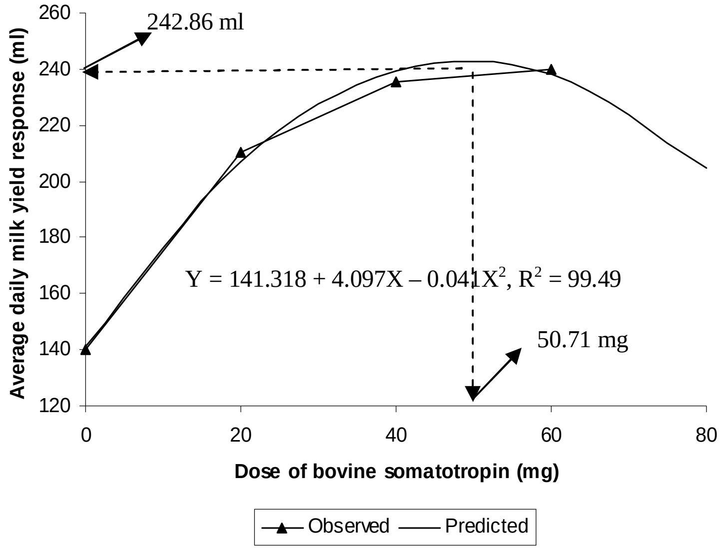

Figure 4a:Observed and predicted optimal dose of bST for maximum daily milk yield response in goats

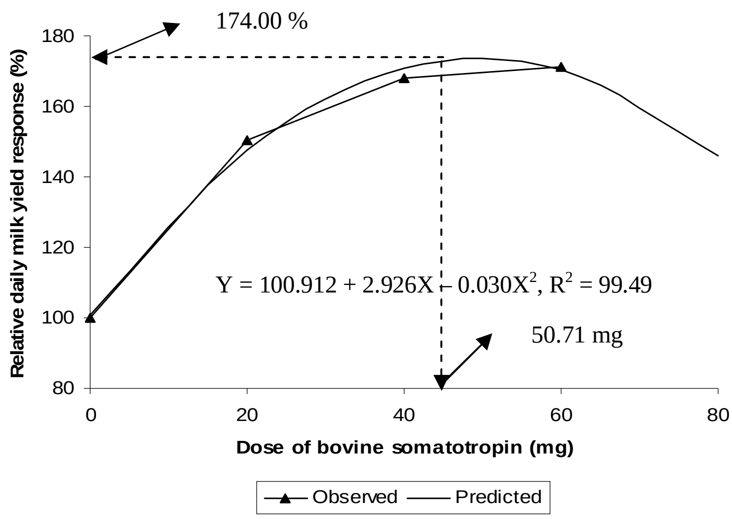

Figure 4b:Observed and predicted optimal dose of bST for maximum relative milk yield response in goats

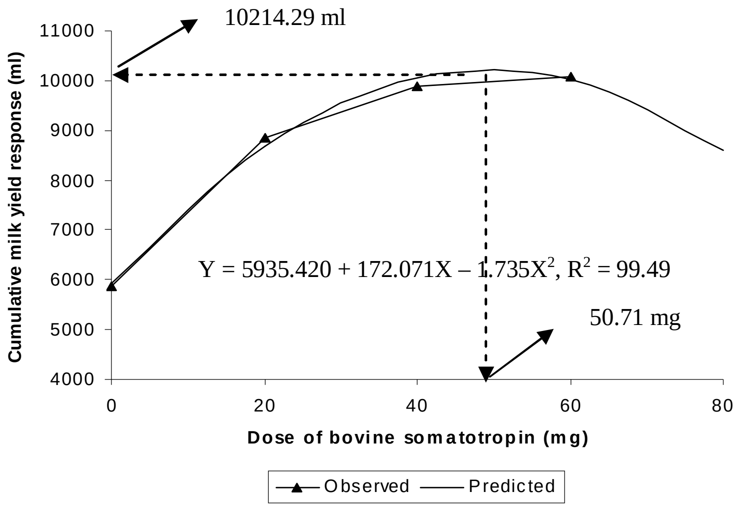

Figure 4c: Observed and predicted optimal dose of bST for maximum cumulative milk yield response in goats

Figure 4c: Observed and predicted optimal dose of bST for maximum milk yield response during entire period (7th – 12th week of lactation) of bST treatment in West African Dwarf goats

CONCLUSION

The administration of bovine somatotropin (bST) (Lactotropina[MR]) in a slow-release formulation to lactating West African Dwarf (WAD) goats during three consecutive cycles of 14 days each (after peak of lactation) increased milk yield by 48 – 78% over the control. Highest predicted response of DMY occurred during the 3rd cycle of bST treatment, thereby changing the shape of the lactation curve positively, improving persistency of lactation and increasing total milk yield per lactation cycle. Doses of bST that elicited optimal milk yield response to bST treatment varied inconsistently with periods of bST treatment (stages of lactation). Therefore, in order to reduce the complexity of differential injections administered with respect to stages of lactation, the uniform optimal dose of 50.71 mg per 2 weeks well-estimated by quadratic equation for the entire stages of lactation studied could be adopted.

ACKNOWLEDGEMENTS

The authors gratefully thank Professor P.I. Rekwot of National Animal Production Research Institute, Ahmadu Bello University, Zaria, Nigeria for providing the bovine somatotropin used in this study. The authors also wish to appreciate Small Ruminant Technical Committee of Teaching and Research Farms of the University of Agriculture, Abeokuta, Nigeria and the personnel of the goat unit of the farm for their assistance.

REFERENCES

Annen, E.L., Collier, R.J., McGuire, M.A., Vicini, J.L., Ballam, J.M., Lormore, M.J. 2004. Effect of modified dry period lengths and bovine somatotropin on yield and composition of milk from dairy cows. *J. Dairy Sci.,* 87: 3746-3761.

Baldi, A., Modina, S., Chelli, F., Gandolfi, F., Pinotti, L., Baraldi-Scesi, L., Fantuz, F., Dell`Orto, V. 2002. Bovine somatoptropin administration to dairy goats in late lactation: Effects on mammary function, composition and morphology. *J. Dairy Sci.,* 85: 1093-1102.

Bauman, D.E., McCutcheon, S.N. 1986. The effects of growth hormone and prolactin on metabolism. In: *Control of digestion and metabolism of ruminants.* Ed. L.P. Milligan, W.L. Grovum, A. Dobson, Pp. 436-455. Englewood Cliffs, NJ: Prentice-Hall.

Bauman, D.E., Vernon, R.G. 1993. Effects of exogenous bovine somatotropin on lactation. *Ann. Review Nutrition,* 13: 437-461.

Bemji, M.N., Osinowo, O.A., Ozoje, M.O., Adebambo, O.A., Aina, A.B.J. 2007. A comparative study on milk yield and pre-weaning growth of West African Dwarf and Red Sokoto goats intensively managed in South-Western Nigeria. *Ghanaian J. Anim. Sci.,* 2&3(1): 81-88.

Boutinaud, M., Rousseau, C., Keisler, D.H., James, H. 2003. Growth hormone and milking frequency act differently on goat mammary gland in late lactation. *J. Dairy Sci.,* 86: 509-520.

Chadio, S.E., Zervas, G., Kiriaku, K., Goulas, C., Menegatos, J.,2000. Effects of recombinant bovine somatotropin administration to lactating goats. *Small Rumin. Res.* 35: 263-269.

Chilliard, Y. 1989. Long-term effects of recombinant bovine somatotropin (rbST) on dairy cow performances. *Ann. Zootech. (Paris)* 37: 159.

Chiofalo, V., Baldi, A., Savoini, G., Polidori, F., Dell`Orto, V., Politis, I. 1999. Response of dairy ewes in late lactation to recombinant bovine somatotropin (rbST). *Small Rumin. Res.,* 34: 119-125.

Davis, J.J., Sahlu, T., Puchala, R., Herselman, M.J., Fernadez, J.M., McCann, J.P., Coleman, S.W. 1999. The effect of bovine somatotropin on production of lactating Angora does with kids. *J. Anim. Sci.,* 17: 17-24.

Dijkstra, J., France., Dhanoe, M.S., Maas, J.A., Hanigan, M.D., Rook, A.J., Beaver, D.E. 1997. A model to describe growth patterns of the mammary gland during pregnancy and lactation. *J. Dairy Sci.,* 80: 2340-2354.

Etherton, T.D., Bauman, D.E. 1998. Biology of somatotropin in growth and lactation of domestic animals. *Physiol. Rev.,* 78: 745-761.

Gallo, L., Bailoni, L., Schiavon, S., Carnier, P., Ramanzin, M., Andrighetto, I., Bittante, G. 1997. Effect of slow-release somatotropin on the pattern of milk yield between and within injection intervals. *J. Dairy Sci.,* 80: 46-51.

Garssen, G.J., Fennema, J., Lambooy, E., Verplanke, J.C. 1989. Short-term treatment of lactating goats with recombinant bovine somatotropin and challenges with glucagons and fructose. Effects on production, metabolism and hormones. Rep. B-366, Inst. Anim. Prod. Schoonoord, Inst. Voor Veeteeltkuhdig, Ziest, The Netherlands.

Google Earth, 2006. http://www.google.earth

Hafez, E.S.E., Jainudeen, M.R., Rosnina, Y. 2000. Hormones, growth factors, and reproduction. *In: Reproduction in farm animals*. Edited by E.S.E. Hafez and B. Hafez, Lippincott Williams and Wilkins Publishers, USA, 7th edition. P. 33-54.

Hartnell, G.F., Franson, S.E, Bauman, D.E., Head, H.H., Huber, J.T., Lamb, R.C., Madsen, K.S., Cole, W.J., Hintz, R.L. 1991. Evaluation of sometribove in a prolonged-release system in lactating dairy cows production responses. *J. Dairy Sci.,* 74: 2645.

James, I.J. 2000. Changes in udder traits of West African Dwarf, Red Sokoto and Sahel goats during pregnancy and lactation and their relationship with partial daily milk yield. *M. Agric. Dissertation.* Department of Animal Production and Health, University of Agriculture, Abeokuta, Nigeria. P. 102.

James, I.J. 2009. Effects of bovine somatotropin on milk yield and mammary gland histology in West African Dwarf goats. *Ph.D Thesis.* Department of Animal Physiology, University of Agriculture, Abeokuta, Nigeria. P. 136.

Jammes, H., Dissenhaus, C., Ouriet, V., Kayser, C., Postel-Vinay, M.C., Djiane, J. 1996. Growth hormone-binding protein in the goat: characterization, evolution under receptor levels. *Domest. Anim. Endocrinol*, 13: 477-489.

McGuffey, R.K., Basson, R.P., Snyder, D.L., Block, E., Harrison, J.H., Rakes, A.H., Emery, R.S., Muller, L.D. 1991. Effect of somidobove sustained-release administration on the lactation performance of dairy cows. *J. Dairy Sci.,* 74: 1263.

Sallam, S.M.A., Nasser, M.E.A., Yousef, M.I. 2005. Effect of recombinant bovine somatotropin administration on milk production, composition and some haemato-biochemical parameters of lactating goats. http://net.shams.edu.eg/esap/12005issue/4.pdf

SYSTAT, 1992. SYSTAT Computer Package, Version 5.02 SYSTAT, Inc. 1800 Sherman Av., Evanston, IL USA, 6021, 708.864.5670.

(Manuscript received: 5th January, 2010; accepted: 30th July, 2010).