ISSN - 2277 - 2755

Journal of
Agricultural Science
and Environment

EFFECTS OF BOVINE SOMATOTROPIN ON CHANGES IN UDDER DIMENSIONS AFTER CESSATION OF MILKING 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

ABSTRACT

A study was conducted to determine the effects of bovine somatotropin (bST) on changes in udder dimensions (UD) including udder length (UL), udder width (UW), udder circumference (UC) and distance between teats (DT) after cessation of milking in twelve West African Dwarf (WAD) goats, which were divided equally into four treatment groups, each comprising three 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 5th week postpartum for 8 weeks. Does were milked twice daily (7:30 am and 7:30 pm). Twenty four hours after the twelfth week, measurement of UD commenced for 35 days. The results revealed that UL, UW, UC and DT were significantly ($p<0.05$) influenced by bST dose, day after cessation of milking and parity and the UD increased with increased doses of bST. There was maximal distension of udder by day 3 to 5 in treated goats than in the control which was on day 2 before declining progressively up to 35th day after cessation of milking. This showed a greater capacity to retain secretions as explained by the larger udder size. Therefore, the administration of bST to WAD goats during lactation extended its effects on mammary glands after cessation of milking and slowed down the rate of udder regression, thus, enabling the potential of bST treated goats for greater milk synthesis in the next lactation cycle.

Keywords: Bovine somatotropin, udder dimensions; WAD goats; WAD sheep

INTRODUCTION

The pattern of changes in the mammary glandular tissue during lactation has been described as the extensive proliferation of milk secreting cells which occurs in early lactation, followed by a progressive increase up to peak of lactation and subsequent decline and death by apoptosis upon cessation of involution (Knight and Wilde, 1993; Dijkstra *et al.,* 1997). The changes have been attributed primarily to hormonal stimulation during pregnancy that continues in early lactation. Such comprise a complex of mammogenic hormones including prolactin, growth hormone, oestrogen, progesterone and relaxin (Bearden and Fuquay, 1980). Their quantitative relationship to mammary growth has been demonstrated in goats (Hayden *et al.,* 1979). The administration of exogenous growth hormone has been shown to alter these changes that occur in the mammary gland to favour milk yield. 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 mammary growth, metabolism and lactogenesis. Mammogenic effect of bST is well documented in lactating cows and non-lactating cows (Hurley, 2006b) and dairy goats (Knight and Wilde, 1993). Treatment of goats with bovine somatotropin during lactation increased mammary gland weight and total DNA with significant increase in number of lactating alveoli and decrease in number of regressing alveoli, thereby delaying mammary involution and improving lactation persistency by slowing down post peak rate of decline (Gallo *et al.,* 1997). The effect on mammary tissue results to dynamic changes in udder dimensions which James (2000) and James and Osinowo (2004) reported to be positively correlated with milk yield and thus, crucial determinants of milk yield. Changes in udder biometrics have been investigated by many researchers in relation to milk yield and composition (RÆnningen *et al*., 1990; Prajapati *et al*., 1995) and milking characteristics (James *et al.,* 2006; Bemji *et al.,* 2008). However, in his findings on West African Dwarf goats, James (2009) reported that udder length, udder width, udder circumference and distance between teats increased correspondingly with increased doses of bST even after cessation of milking, though not consistent. He also observed that it increased the time of maximum udder distension which has been reported (Fleet and Peaker, 1978) to favour milk production in the next lactation because of the increased udder capacity for milk synthesis and retention. The pattern of udder changes after cessation of milking has been studied quantitatively using parameters such as RNA and DNA contents (Stefanon *et al.,* 2002). However, in the present study, the udder dimensions studied were udder length, udder width, udder circumference and distance between teats. Since the visible and measurable size of the udder after cessation of milking largely reflect milk secretion capacity in the next lactation cycle (Gülay *et al.,* 2004), therefore, there is the need to study the effects of bST on changes in udder dimensions after cessation of milking in West African Dwarf goats.

MATERIALS AND METHODS

Description of the experimental site

The experiment was conducted at the goat unit of the College of Animal Science and Livestock Production Teaching and Research Farm, University of Agriculture, Abeokuta. It 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

Twelve lactating West African Dwarf goats of 1st and 2nd parities with ages between 1.5 and 3 years and whose weights ranged from 11-16 kg were used for the study. 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. *Panicum maximum* grass and concentrate feed supplement, consisting of about 17 and 5% crude protein were fed to the goats at about 0.3-0.5 kg/

head/day and 1.0 kg/head/day, respectively. The proximate composition of the grass consists 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

The does were divided equally into four treatment groups, each group comprising three does with live-weight equalization among treatment groups. The first group, which was the control (T_0) received no bovine somatotropin (bST) injection while the remaining three groups received bST injections at different doses: 20 mg (T_1), 40 mg (T_2) and 60 mg (T_3). 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 in National Animal Production Research Institute (NAPRI), Nigeria and the study on the effect of recombinant bovine somatotropin (bST) administration on milk production, composition and some haemato-biochemical parameters of lactating goats in Egypt, by Sallam *et al.* (2005) also provided basis for the selection of the doses. The bST, Lactotropina ^{MR}, division Sanidad Animal, Eli Lilly CO., Mexico is in a sustained-release formulation for 14 days interval. The injections of bST were done at the left and right scapular regions alternately every 14 days commencing from 5th to 11th week of lactation with a total of 4 injections per doe.

Data collection

The does were milked twice daily at 7:30 a.m. and 7:30 p.m. for 56 days commencing from 5th to 12th week of lactation. Twenty-four hours after the last milking on the 12th week of lactation, udder dimensions (cm) including udder length (UL), udder width (UW), udder circumference (UC) and distance between teats (DT) were measured daily from the does as described by Amao (1999) for 35 days in order to determine the pattern of changes in udder after cessation of milking in goats treated with bST and the control.

Statistical analysis

Data generated on UL, UW, UC and DT measured after cessation of milking was analyzed by Systat Analytical Computer Package (SYSTAT, 1992). The statistical model used was:

Y_{ijkl} $= \mu + A_i + B_j + C_k + A*B_{ij} + A*C_{ik} + \varepsilon_{ijkl}$

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 after cessa tion of milking (j = day 1– day 35)

C_k =Fixed effect of kth parity (k = 1st & 2nd)

$A*B_{ij}$ = The interaction between ith bST dose and jth day after cessation of milking

$A*C_{ik}$ = The interaction between ith bST dose and kth parity of does

ε_{ijkl} = Random error associated with each record.

Tukey's Honest Significant Difference (HSD) was used to separate means where significant differences exist (SYSTAT, 1992).

Table 1: Group size, body weight, udder length, udder width, udder circumference, distance between teats prior to cessation of milking in West African Dwarf goats during lactation

Traits	Treatment group bST dose 0 mg(T_0)	20 mg(T_1)	40 mg(T_2)	60 mg(T_3)
No. of goats	3	3	3	3
Body weight,[1] kg	15.27	15.05	15.10	15.03
Udder length,[1] cm	9.61	9.97	9.93	10.22
Udder width,[1] cm	7.62	7.87	7.91	8.21
Udder circumference,[1]cm	24.60	26.48	24.50	26.39
Distance between teats,[1]cm	8.29	8.17	8.66	7.68
Milk yield, ml per day[1]	149.26	148.90	149.01	150.10
Days in milk[1]	85	84	85	84

[1]Means of treatment groups did not differ significantly ($p>0.05$)

RESULTS AND DISCUSSION

The twelve slaughtered goats had similar body weights and udder dimensions, stages of lactation and milk yield at the beginning of the experiment (Table 1).

Changes in udder dimensions including UL, UW, UC and DT were significantly ($p<0.05$) affected by bST dose, day after cessation of milking and parity. Udder dimensions of the does increased correspondingly with increased levels of bST doses, though not consistently. Invariably, it shows that the effects of bST on the treated does extended to period after cessation of milking. Thus, the higher mammary tissue that was laid down during lactation when the alveoli cells were still more active by does treated with bST, still maintained its superiority during mammary regression. This in essence, enhances its milk secretion capacity in the next lactation cycle. The mean UL was 7.22, 9.68, 9.40 and 10.24 cm; the mean UW was 6.15, 6.70, 7.45 and 6.51 cm; the mean UC was 19.11, 23.73, 22.05 and 22.17cm and the mean UW was 6.84, 7.82, 7.95 and 6.86 cm for T_0, T_1, T_2 and T_3 respectively (Figure 1,a,b,c,d). Second parity does had larger udder dimensions than the first parity does with mean values of 9.35 and 8.95 cm, 6.82 and 6.58 cm, 22.81 and 20.73 cm and 7.74 and 6.70 for UL, UW, UC and DT respectively. This finding corroborates the finding of Akpa *et al.* (1998) and Amao (1999) and it could be attributed to further growth and development of mammary gland whose increase in mass is positively correlated with increase in lactation number and cycles (Knight and Wilde, 1993). In T_0, UL increased from 9.61 cm on the 1st day after cessation of milking to 10.04 cm on the 2nd day after cessation of milking and subsequently decreased to 5.44 cm on the 35th day after cessation of milking. In T_1, UL increased from 9.97 cm on the 1st day after cessation of milking to 10.90 cm on the 5th day after cessation of milking and subsequently decreased to 8.64 cm on the 35th day after cessation of milking. In T_2, UL increased from 9.93 cm on the 1st day after cessation of milking to 11.73 on the 4th day after cessation of milking and subsequently decreased to 8.20 cm on the 35th day after cessation of milking. In T_3, UL increased from 11.22 cm on the 1st day after cessation of milking to 11.62 cm on the 4th day after cessation of milking and subsequently decreased to 9.52 cm on the 35th day after cessation of milking. In T_0, UW increased from 7.62 cm on the 1st day after cessation of milking to 7.85 cm on the 2nd day after cessation of milking and subsequently decreased to 4.75 cm on the 35th day after cessation of milking. In T_1, UW increased from 7.87 cm on the 1st day after cessation of milking to 8.54 cm on the 5th day after cessation of milking and subsequently decreased to 5.87 cm on the 35th day after cessation of milking. In T_2, UW increased from 7.91 cm on the 1st day after cessation of milking to 9.59 cm on the 5th day after cessation of milking and subsequently decreased to 5.52 cm on the 35th day after cessation of milking. In T_3, UW increased from 8.21 cm on the 1st day after cessation of milking to 8.31 cm on the 4th day after cessation of milking and subsequently decreased to 5.51 cm on the 35th day after cessation of milking. In T_0, UC increased from 24.60 cm on the 1st day after cessation of milking to 25.44 cm on the 2nd day after cessation of milking and subsequently decreased to 15.64 cm on the 35th day after cessation of milking. In T_1, UC increased from 26.48 cm on the 1st day after cessation of milking to 29.34 cm on the 5th day after cessation of milking and subsequently decreased to 20.14 cm on the 35th day after cessation of milking. In T_2, UC increased from 24.50 cm on the 1st day after cessation of milking to 29.20 on the 3rd day after cessation of milking and subsequently decreased to 17.40 cm on the 35th day after cessation of milking. In T_3, UC increased from 26.39 cm on the 1st day after cessation of milking to 27.56 cm on the 4th day after cessation of milking and subsequently decreased to 17.59 cm on the 35th day after cessation of milking. In T_0, DT increased from 8.29 cm on the 1st day after cessation of milking to 8.43 cm on the 2nd day after cessation of milking and subsequently decreased to 5.56 cm on the 35th day after cessation of milking. In T_1, DT increased from 8.17 cm on the 1st day after cessation of milking to 8.90 cm on the 5th day after cessation of milking and subsequently decreased to 7.20 cm on the 35th day after cessation of milking. In T_2, DT increased from 8.66 cm on the 1st day after cessation of milking to 9.59 on the 4th day after cessation of milking and subsequently decreased to 6.66 cm on the 35th day after cessation of milking.

In T_3, DT increased from 7.68 cm on the 1st day after cessation of milking to 7.91 cm on the 4th day after cessation of milking and subsequently decreased to 5.71 cm on the 35th day after cessation of milking (Figure 1). The observation that udder dimensions increased from 1st day of udder regression, peaked on the 2nd and 5th day after cessation of milking during udder regression in both bST treated goats and the control, and then after decreased progressively up to 35th day of udder regression in WAD does is a normal physiological process that occurs in lactating animals after cessation of milking. Noble and Hurley (1999) reported that, following cessation of milk removal in goats, the mammary gland reaches maximal distension, and secretion rate is reduced dramatically by day 3 of milk stasis. The reduction has been implicated on combined local inhibitory factors (LIF) and actions of intramammary pressure as opposed to hormonal factors associated with milking (Henderson and Peaker, 1987).

After day 3 of milk stasis, milk specific components of the secretions decreased while levels of blood-derived components and *de novo* synthesis of lactoferrin increased (Hurley *et al.,* 2006b). Consequently, luminal alveolar area reduces as secretions are absorbed and stromal area increases within the first week following milk stasis (Holst *et al.,* 1987). By day 28, the collapsed alveolar structures remaining were considerably smaller than during lactation, with a very small lumen. The maximal distension of udder by day 3 to 5 observed in T_1, T_2 and T_3 vis-à-vis the control (T_0) before declining progressively up to 35th day after cessation of milking during udder regression, showed a greater capacity to retain secretions as explained by the larger udder size. Fleet and Peaker (1978) suggested that this could favour milk production in the next lactation. In essence, rate of udder regression appeared to be slower in goats injected with bST than in the control but modeling the pattern of changes in udder dimensions through regression equations might be necessary to validate the statement.

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) extended its effects on changes in udder dimensions after cessation of milking, increased the dimensions of the udder and the time of udder distension thus enabling the potential of bST treated goats for greater milk synthesis in the next lactation cycle.

ACKNOWLEDGEMENTS

The authors wish to thank the Chairman of Small Ruminant Technical Committee of Teaching and Research Farms of the University of Agriculture, Abeokuta and the personnel of the goat unit of the farm for their assistance. Our thanks also go to Prof. P. I. Rekwot of the National Animal Production Research Institute (NAPRI), Shika, Ahmadu Bello University, Zaria for providing the growth hormone used for the study.

REFERENCES

Akpa, G.N., Duru, S., Dim, N.I., Alawa, J.P., Jokthan, G.E. 1998. Sources of variations in udder traits of Red Sokoto goats. In: Oduguwa, O.O., Fanimo, A.O., and Osinowo, O.A. (Eds.). *Animal Agriculture in West Africa: The sustainability question.* Proc. of Silver Anniversary Conference of the Nig. Soc. For Anim. Prod. and the inaugural Con. of the West African Soc. for Anim. Prod. (WASAP) held at Gateway Hotel, Abeokuta, Nigeria, 21 – 26th March, 1998. Pp. 650.

Amao, O.A. 1999. Evaluation of udder traits of West African Dwarf and Red Sokoto goats. *M. Agric. Dissertation.* Department of Animal Production and Health, University of Agriculture, Abeokuta, Nigeria. Pp. 116.

Bearden, H.J., Fuquay, J.W. 1980. *Applied animal reproduction*. Reston and Publishing Company. Inc., p.110 - 118.

Bemji, M.N., Adepoju, I.O., De CAMPOS, J.S., James, I.J. 2008. Udder morphology, teat placement and milking characteristics in West African Dwarf goats. *Proc. of the 13h Ann. Conf. of Anim. Sci. Assoc. of Nig. (ASAN)*, September 15-18, 2008, Ahmadu Bello University, Zaria, Nigeria.

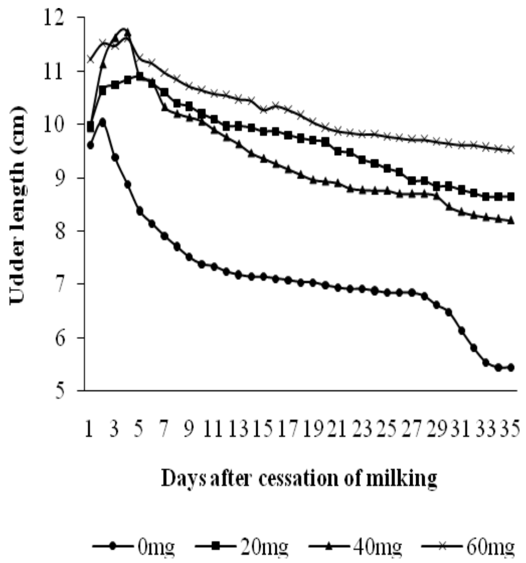

Figure 1a. Changes in udder length after cessation of milking in West African Dwarf goats

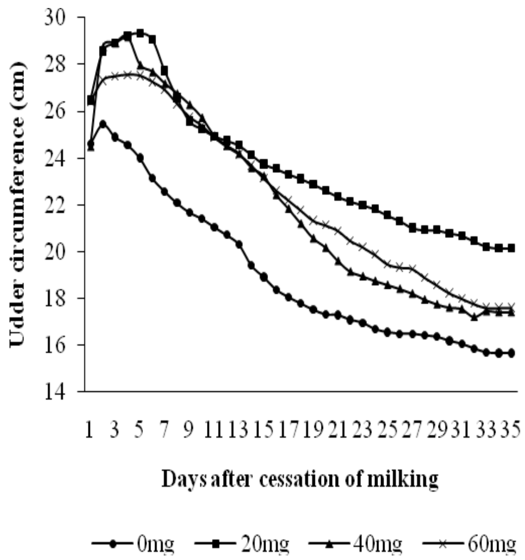

Figure 1c. Changes in udder circumference after cessation of milking in West African Dwarf goats

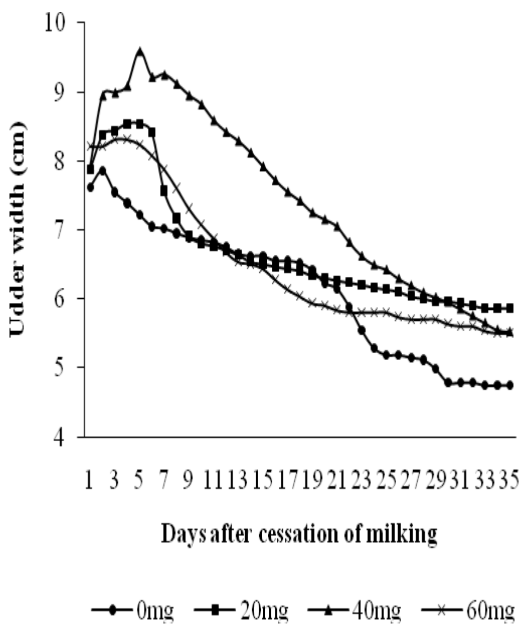

Figure 1b. Changes in udder width after cessation of milking in West African Dwarf goats

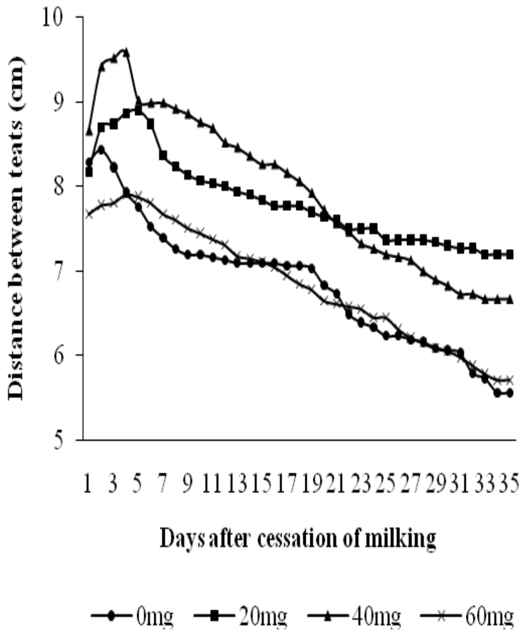

Figure 1d. Changes in distance between teats after cessation of milking in West African Dwarf goats

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

Fleet, I.R., Peaker, M. 1978. Mammary function and its control at the cessation of lactation in goat. *J. Physiol*., 279:491-507.

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.

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

Gülay, M.Ş., Garcia, A.G., Hayen, M.J., Wilcox, C.J., Head, H.H. 2004. Responses of Holstein cows to different bovine somatotropin (bST) treatments during the transition period and early lactation. *A. A. J. Anim.* Sci., 17:784-793.

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.

Hayden, T. J., Thomas, C.R., Forsyth, I.A. 1979. Effect of number of young born (litter size) on milk yield of goats: Role for placental lactogen. *J. Dairy Sci.,* 62: 53.

Henderson, A.J., Peaker, M. 1987. Effect of removing milk from the mammary ducts and alveoli, or of diluting stored milk, on the rate of milk secretion in goat. *Q. J. Exp. Physiol.,* 72:13-19.

Holst, B.D., Hurley, W.L., Nelson, D.R. 1987. Involution of the bovine mammary gland: histological and ultrastructural changes. *J. Dairy Sci.,* 70: 935-944.

Hurley, W.L. 2006b**.** Mammary gland involution and dry period. http://classes.aces.uiuc.edu/AnSci308/involution.html

Hurley, W.L. 2006a. Mammary gland development during pregnancy. In: Mammary Development Resources. http://classes.aces.uiuc.edu/AnSci308/mammary development.html.

James, I.J. 2000**.** Changes in udder traits of West African Dwarf, Red Sokoto and Sahel goats during pregnancy and lactation and their effects on 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.

James, I.J., Osinowo, O.A., Oni, O.A. 2006. Relationship between teat dimensions and milkability of West African Dwarf goats. *Proc. of the 31st Ann. Conf. of Nig. Soc. For Anim. Prod. (NSAP)*, March 12-15, 2006, Bayero University, Kano, Nigeria.

James, I.J., Osinowo, O.A. 2004. Changes in udder size and live-weight of West African Dwarf, Red Sokoto and Sahel goats during lactation and their phenotypic relationship with partial daily milk yield. *Nig. J. Anim.*

Prod., 31(1): 119-129.

Knight, C.H., Wilde, C.J. 1993. Mammary cell changes during pregnancy and lactation. *Livest. Prod. Sci.,* 35: 3-19.

Noble, M.S., Hurley, W.L. 1999. Effect of secretion removal on bovine mammary gland function following an extended milk stasis. *J. Dairy Sci.,* 82: 1723-1730.

Prajapati, K.B., Singh, D.V., Patel, J.P., Patel, J.B. 1995. Dimensions of various types of udder and teat and milk yield in Kankrej cows. *Indian J. Dairy Sci.,* 48(11): 654 - 656.

RÆnningen, O., Reitan, A.D. 1990. Teat length and penetration into teat cup during milking in Norwegian Red cattle. *J. Dairy Res.,* 57: 165-170.

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

Stefanon, B., Colitti, M., Gabai, Knight, C.H., Wilde, C.J. 2002. Mammary apoptosis and lactation persistency in dairy animals. *J. Dairy Res.,* 69: 37-52.

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

(Manuscript received: 23rd July, 2009; accepted: 5th October, 2009).