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Lactation curve parameters and characteristics of West African dwarf goats

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Abstract

Parameters and characteristics of lactation curve are useful for assessing total milk yield, milk peak and persistency of lactation of a breed. This study was carried out using West African Dwarf goats with purpose of determining the lactation curve parameters of WAD in Nigeria with aim that when it is applied on farms it helps to estimate animal requirement for diet formulation and early detection of goats to be culled for low milk production. In this study, twenty-one lactating WAD in their 1st and 2nd parity were used to determine the lactation curve parameters and characteristics of WAD goats in Nigeria. The goats were divided into three treatment groups comprising of seven animals each. The first group was not administered with oxytocin, while the second and third groups received 2 IU and 4 IU exogenous oxytocin, respectively. The experiment commenced five days post-partum and lasted for 12 weeks. Data collected were fitted into Wood model to generate lactation curve parameters. The mean "a", "b" and "c" parameters were 361.69 ± 2.43, 0.414 ± 0.03 and 2.972 ± 2.80, respectively with R^2 value of 99.3 %. Mean for (PY), (PW) and (PSS) were 340.45 ± 11.35, 2.288 ± 0.14 and 2.304 ± 0.22. Oxytocin ($P<0.05$) influenced "a", "b", "PW", "PY" and "R^2". Litter size ($P>0.05$) influenced "a", "b", "PW" and "PY". Parity ($P>0.05$) influenced "a", "b" and "PW". Parameter "a" was higher with 4 IU, 2 IU and then 0 IU respectively. Parameter "b" was higher with 0 IU, 4 IU and while "c" was higher with 2 IU. Does with litter size 2 had higher "a" but lower "b". Does in first parity had higher "a". WAD goats curve parameters showed that WAD goats had smaller initial milk yield 'a' with high "b" and "c". This indicated that period of lactation in WAD goats is short. Persistency value for WAD goats was low. Thus, the ability of WAD does to maintain milk production throughout the lactation period was low. The findings revealed that oxytocin, litter size and parity had noticeable influence on "a", "b" and "c", peak week, peak yield. Oxytocin injected does and does with twin kids had higher initial milk yield 'a' but lower 'b', thus the tendency of extending lactation period.

Keywords: WAD goat, lactation curve, wood equation, oxytocin, litter size, parity, physiology and lactation curve

Paramètres et caractéristiques de la courbe de lactation des chèvres naines d'Afrique de l'Ouest

Résumé

Les paramètres et les caractéristiques de la courbe de lactation sont utiles pour évaluer la production laitière totale, le pic laitier et la persistance de la lactation d'une race. Cette étude a été réalisée sur des chèvres naines d'Afrique de l'Ouest dans le but de déterminer les paramètres de la courbe de lactation du NAO au Nigeria dans le but que, lorsqu'il est appliqué dans les fermes, il aide à estimer les besoins des animaux pour la formulation de l'alimentation et la détection précoce des chèvres à abattre pour faible production de lait. Dans cette étude, vingt et un NAO en lactation dans leur 1ère et 2ème parité ont été utilisés *pour déterminer les paramètres et les caractéristiques de la courbe de lactation des chèvres NAO au Nigeria. Les chèvres ont été divisées en trois groupes de traitement comprenant chacun sept animaux. Le premier groupe n'a pas reçu d'ocytocine, tandis que les deuxième et troisième groupes ont reçu respectivement 2 UI et 4 UI d'ocytocine exogène. L'expérience a commencé cinq jours après l'accouchement et a duré 12 semaines. Les données recueillies ont été intégrées au modèle de Wood pour générer les paramètres de la courbe de lactation. Les paramètres moyens « a », « b » et « c » étaient de 361,69 ± 2,43, 0,414 ± 0,03 et 2,972 ± 2,80, respectivement avec une valeur R2 de 99,3 %. La moyenne pour (PY), (PW) et (PSS) était de 340,45 ± 11,35, 2,288 ± 0,14 et 2,304 ± 0,22. L'ocytocine (P<0,05) a influencé « a », « b », « PW », « PY » et « R2 ». La taille de la portée (P>0,05) a influencé « a », « b », « PW » et « PY ». La parité (P>0,05) a influencé « a », « b » et « PW ». Le paramètre « a » était plus élevé avec 4 UI, 2 UI puis 0 UI respectivement. Le paramètre « b » était plus élevé avec 0 UI, 4 UI et « c » était plus élevé avec 2 UI. Les femelles de taille de portée 2 avaient un « a » supérieur mais un « b » inférieur. Les femelles en première parité avaient un « a » plus élevé. Les paramètres de la courbe des chèvres NAO ont montré que les chèvres NAO avaient un rendement laitier initial «a» plus faible avec des «b» et «c» élevés. Cela indique que la période de lactation des chèvres NAO est courte. La valeur de persistance des chèvres NAO était faible. Ainsi, la capacité de NAO à maintenir la production de lait tout au long de la période de lactation était faible. Les résultats ont révélé que l'ocytocine, la taille de la portée et la parité avaient une influence notable sur « a », « b » et « c », la semaine de pointe, le rendement maximal. L'ocytocine injectée chez les biches et les biches avec des chevreaux jumeaux avait un rendement laitier initial plus élevé « a » mais « b » inférieur, d'où la tendance à prolonger la période de lactation.*

Mots-clés : chèvre NAO, courbe de lactation, équation du bois, ocytocine, taille de portée, parité, physiologie et courbe de lactation

Introduction

West African dwarf goat is a very miniature milk-producing goat with an average length of lactation of 127 days (Jaitner *et al*., 2006).Lactation Curve is a graph that shows how quantity of milk produced and period of lactation are related (Fadlelmoula *et al*., 2007). Lombaard (2006) defined lactation curve as graph of milk yield with an elevation of relatively high rate to the point where highest production is attained, thereafter declined at a gradual rate until end of lactation. The duration of lactation will be lengthier if the rate of decrease in milk yield is slow and low if the rate of decrease in milk yield is rapid. Lactation duration is lengthier in animals with flatter lactation curve than those animals with a curve of fast increase in daily milk production from parturition to peak and a fast decrease. The estimation of the lactation curve parameters gives information about economic and biological productivity of dairy animals and also influences farm activities decisions such as milking schemes, culling, fertility and health status monitoring (Lombaard, 2006; Gołębiewski *et al*., 2011; Macciotta *et al*., 2011; Elahi Torshizi *et al*., 2011). Wood (1967), Cobby and Le Du (1978) are some models that can be used to fit the animal's lactation curves (Chang *et al*., 2001; Fernandez *et al*., 2002). Factors such as age, parity, parturition season, parturition year, and service period affect lactation curve shape parameters, persistency and yield traits (Rekik *et al*., 2003; Osorio *et al*., 2005; Kumar and Singh, 2006). The objective of this study was to understand the underlying pattern of milk production of West African dwarf (WAD) goats in Nigeria and also to know if factors such as hormone, stage of parity and number of kids can affect the pattern.

Materials and methods

Study location

The study was performed at a Small Dairy Goat Research Farm situated at Camp in Abeokuta, Ogun State. The project place falls within the Rain Forest Vegetation zone of South-West Nigeria at latitude of 7°11′ 30.65″N, longitude of 3°25′55.67″E (Google Earth, 2013). The region of the research has about annual rainfall of 1037 mm, temperature of 34.7°C and humidity and 82 %.

Ethical approval

All experimental protocol and procedures employed in this research were reviewed and approved by the Research Supervisory Committee of the Department of Animal Physiology, College of Animal Science and Livestock Production, Federal University of Agriculture, Abeokuta, Ogun State, Nigeria.

Research animals and their management

Twenty-one lactating West African Dwarf does in their first and second parities and of liveweight ranged from 9.5-16.5 kg were used for the experiment. The does were kept under an intensive management system of well ventilation and slated floor. The lactating does were fed in the morning with about 0.3-0.5kg/head/day of concentrate feed and with fresh *Panicum maximum* grass of 1.0 kg/head/day in the evening.

Experimental procedure

The twenty-one lactating does were divided into three groups of seven does each. Liveweight of the does were equalized among the treatment groups. The control group (T0) did not receive injection of oxytocin (0 IU), second group (T_1) received 2 IU and third groups (T_2) were given 4 IU oxytocin once a week for twelve weeks. Data collection started five days after kidding. Separation of the kids from their dam started 7:00pm and an interval of 5 minutes was given between separations to avoid clash of milking time. Residual milk was removed by injection of 1 IU synthetic oxytocin intramuscularly at the hind limb after separation. At 7:00am the next day (12 hours) does were injected with oxytocin according to their group and hand milked.

Lactation curve

Wood (1967) model was used to estimate lactation curve parameters and characteristicsof WAD does treated with oxytocin levels 0 IU, 2 IU and 4 IU.

Wood's model: $\mathbf{Y(t) = a\, t^{b}\, e^{-ct}}$

Where, Y (t): daily milk production at day t;

"a" represents parameter associated with yield at the beginning of lactation,

"b" indicates parameter associated with the increasing phase before peak yield, and

"c" depicts parameter associated with the decreasing phase after peak yield.

The peak week (PW) = b / c

peak yield (PY) = $a\,(b/c)^{b} e^{-b}$,

The persistency (PSS) of lactation: $S = -(b+1)\ln(c)$ (Tekerli *et al.*, 2000).

Statistical analysis

The SAS 9.1 version programme was used to calculate curve parameters 'a', 'b', 'c', PW, PY and PSS and estimation of coefficient of determination (R^2). Analysis of variance (ANOVA) was carried out to test the oxytocin dosage, litter size and parity effect on the parameters and characteristics of the curve **in 3 x 2 x 2 factorial design**.

The statistical model:

$$Y_{ijkl} = \mu + A_i + B_j + C_k + \varepsilon_{ijkl} \quad (2)$$

Where;

Y_{ijkl} =Trait of interest

μ =Population mean

A_i =Fixed effect of i^{th} dose of oxytocin administration (i=0, 2, 4 IU)

B_j = Fixed effect of j^{th} parity (j = 1^{st} and 2^{nd})

C_k = Fixed effect of k^{th} litter size (k = 1and 2)

ε_{ijkl} =Random Residual Error

Results and discussion

Lactation curve parameter of WAD goats

Means and standard errors of lactation curve parameters are shown in Table 1.The means obtained for "a" was 361.69 ± 2.43 volume and is less than 1120 ± 0.002 volume obtained by *Ayasrah et al. (2013) in Damascus goats* and of 700 ± 0.04 volume obtained by (Kamel, 2008) in Shami goats. WAD goats are half the size of average goats and this could be attributed to the smaller initial milk yield compared to other goat breeds. The "b" parameter of WAD goats was 0.414 ± 0.03 (Table 1), this was higher than 0.35 ± 0.0003 obtained by *Ayasrah et al. (2013) in Damascus goats and of 0.14* ± 0.007, 0.13 ± 0.005 obtained by Cigdem *et al*. (2009) in Bornova and Saanen goats respectively. Waheed and Kahn (2013) reported a lower "b" of 0.3690 ± 0.04 for Beetal goats. This shows that rate of rising in milk production in WAD goats is high. The "c" parameter of WAD goats was 2.972 ± 2.80 (Table 1), this is more than 0.08 ± 0.000 obtained by *Ayasrah et al. (2013) in Damascus goats. The "c" parameter of WAD is also* lower than 0.21 ± 0.01 reported by Kamel (2008) on Shami goats. Cigdem *et al*. (2009) reported a "c" parameter value of 0.12 ± 0.53 and 0.14 ± 0.41 in Bornova and Saanen goats respectively. Waheed and Kahn (2013) reported a "c" value lower 0.1196 ± 0.01 for Beetal goats. The findings in this present study revealed that the rate of descend of milk yield after peak in WAD goats was high as lactation progressed.

Table 1. **Shows means and standard errors of WAD lactation curve parameters**

Parameters	Mean ± S.E
a (volume)	361.69 ± 2.43
b	0.414 ± 0.03
C	2.972 ± 2.80

[a] parameter associated with yield at the beginning
[b]parameter associated with the ascending phase before peak yield
[c] parameter associated with the decreasing phase after peak yield

Lactation curve characteristics of WAD goats

Means and standard errors of lactation curve characteristics are shown in Table 2. The coefficients of determination (R^2) of the curve of WAD goat was 99.3 ± 0.01 and as such indicated good fit of the wood model to the data. Cigdem *et al*. (2009) reported lower R^2 of 0.86 and 0.83 for Bornova and Saanen goats, respectively. Waheed and Kahn (2013) reported similar R^2 value of 0.98 for Beetal goats. The mean of peak milk yield in this study was 340.45 ± 11.35 (Table 2). The result was lower than 1290 ± 0.007 vol obtained by Ayasrah *et al.* (2013) in Damascus goats. The present result on "PY" of WAD goats was lower than 1800 volume in Zaraibi goats reported by Hamed (2010) and also 1300 volume reported by Waheed and Kahn (2013) in Beetal goats. *However, it was similar to 347 volume reported by Ruvuna et al. (1995) on Galla and East African goats. M*eans and standard error of "PW" of lactation in WAD goats was 2.288 ± 0.14 (Table 2). *Ayasrah et al. (2013) reported a higher "PW" of* 3.93 ± 0.008 for *Damascus goats.* Hamed (2010) reported a higher "PW" of 3.94 ± 0.08 in Zaraibi goats. Waheed and Kahn (2013) *reported a higher peak week of* 3.10 in Beetal goats. *M*eans and standard error of "PSS" of lactation in WAD goats was 2.304 ± 0.22 (Table 2). The result is lower than 0.86±0.0003 obtained by *Ayasrah et al.* (2013) *in Damascus goats. Persistency value for WAD goats was lower than* 60.17 *found by* Waheed and Kahn (2013) in Beetal goats. The result indicated ability of WAD does to maintain milk production throughout the lactation period was low. The obtained result of persistency for WAD goats showed that normal process of mammary gland involution was high. Involution of mammary gland has been identified by (Stefanon *et al*. 2002; Millier 2013) to be influenced by the rate of apoptosis occurring in the aveoli**.**

Table 2. Shows means and standard errors of WAD lactation curve characteristics

Parameters	Mean ± S.E
R^2 (%)	99.3 ± 0.01
PY (vol/week)	340.45 ± 11.35
PW (week)	2.288 ± 0.14
PSS	2.304 ± 0.22

R^2 = coefficient of determination,
PY = peak yield,
PT = peak week
PSS = persistency in lactation curve of WAD goat

Effects of oxytocin on lactation curve parameters

Lactation curves of WAD goats injected with oxytocin are shown in Figure 1.Table 3 shows the means and standard errors effects of oxytocin on lactation curve parameters of WAD does. The results showed that administration of exogenous oxytocin had noticeable effect on lactation curve parameters of *a* and *b* ($P < 0.05$). However, no effect of oxytocin was observed on parameter c (Table 3). Oxytocin 4 IU and 2 IU were the same for "a" parameter, but differed significantly ($P < 0.05$) from the "a" parameter of 0 IU (Table 3). Oxytocin 4 IU and 2 IU doses had initial milk yield of 396.80 ± 19.91 and 391.73 ± 12.27 respectively and is higher than 285.68 ± 17.86 of initial milk yield obtained from 0 IU. This is expected since oxytocin increase milk yield due to its contraction effect on the myoepithelial cells of the mammary gland (Knight *et al.,* 1994; Pfeilsticker *et al.,* 1996) and thus, encourages more milk secretion and evacuation. Higher value of 0.64 ± 0.04 for "*b*" was observed in 0 IU and was lower than 0.27 ± 0.04and 0.36 ± 0.04 obtained for oxytocin doses 2 IU and 4 IU respectively. This indicated that oxytocin was able to slow down the rate of rising of milk production to the peak milk yield due to its ability to enhance proliferation and differentiation of the mammary myoepithelial cells (Sapino *et al.,* 1993).

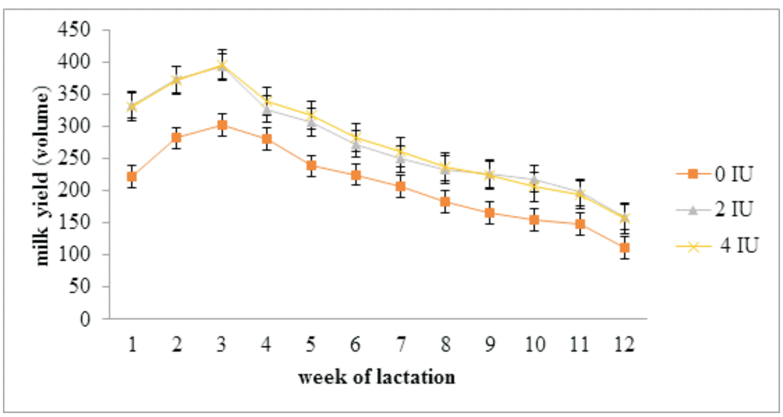

Figure 1. Lactation curve of WAD goats administered with different levels of oxytocin

Effect of litter size (single or twins) on lactation curve parameters

Lactation curves of WAD goats with different litter sizes are shown in Figure 2.Table 3 shows the means effects of litter size on lactation curve parameters of WAD does. Litter size (single or twins) affected lactation curve parameters (a and b) ($P < 0.05$) and not parameter c (Table 3). Litter size 2 significantly ($P < 0.05$) differed for "a" parameter compared with litter size 1. Litter size 1 significantly ($P < 0.05$) differed for "b" parameter compared with litter size 2. Does with single kid had higher rate of rising in milk production before peak compared to does with twin kids (Table 3). The result for initial milk yield "a" was in agreement with that reported by (Rojo-Rubio *et al*., 2016) for Alpine, Saanen and Anglo-Nubian goats. *Ayasrah et al. (2013) observed no* significant effect of litter size on initial milk yield *in Damascus goats*. The result for initial milk yield was also not in agreement with earlier reports (Kamel, 2008 in Shami goats., Hamed 2010 in Zaraibi goats and Akpa *et al.,* 2001 in Red Sokoto goats). The reason for higher initial milk yield with twin kids could be as a result of greater stimulation effect exerted on mammary gland by more than a single kid suckling on the udder (Salvador and Martínez, 2007). Does with single kid had higher rate of rising "b" in milk production before peak than does with twin kids. The rate of rising in milk production to peak decreased as litter size increased. *Ayasrah et al. (2013) observed no* significant effect of litter size on rate of rising in milk production to peak *in Damascus goats*. The result for rate of ascending of milk production before peak was also not in agreement with that reported (Kamel 2008 in Shami goats; Hamed 2010 in Zaraibi goats and Akpa *et al.,* 2001 in Red Sokoto goats*)*. This indicated that twin litter size was able to slow down the rate of rising of milk production to the peak milk yield due to higher number of suckling that will evacuate milk from the alveoli thus, it will take the secretory milk gland longer time to reach peak of milk production.

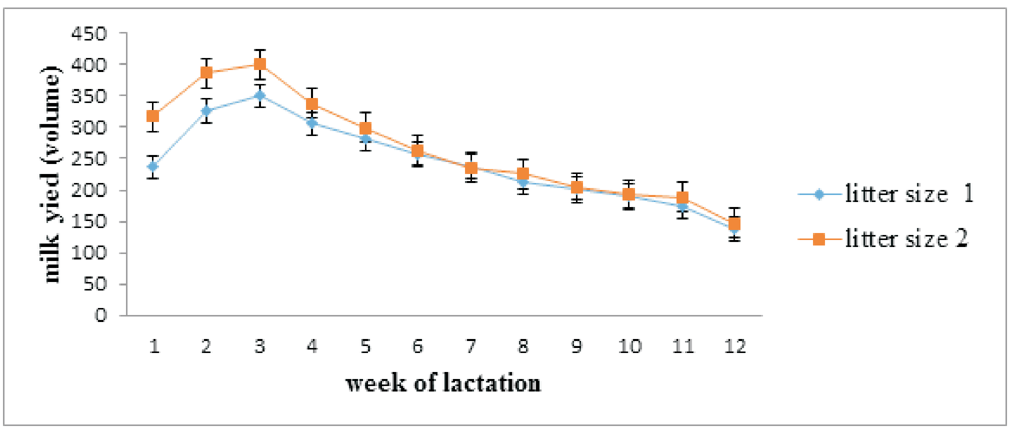

Figure 2. lactation curve of WAD goats with different litter sizes

Effect of parity on lactation curve parameters

Lactation curves of WAD does in different parities are drawn in Figure 3. Table 3 shows the means effects of parity on lactation curve parameters of WAD does. Parity significantly ($P < 0.05$) affected lactation curve parameter "*a*" but had no significant effect on parameters "b" and "c" (Table 3). The results indicated that "a" parameter of does in first parity differed ($P < 0.05$) from that of does in second parity. The results showed that does in their first parity had higher "*a*" for initial milk yield than does in second parity. Initial milk yield did not increase with advancing parity from first to second parity. The result of the present work agreed with the work of Hamed (2010) on Zaraibi goats and Akpa *et al*. (2001) on Red Sokoto goat but not in line with the report of Kamel Fatal (2008) in Shami goats who found that parity had no significant influence on initial milk yield. It is also in agreement with the report of *Ayasrah et al.* (2013) in Damascus goats.

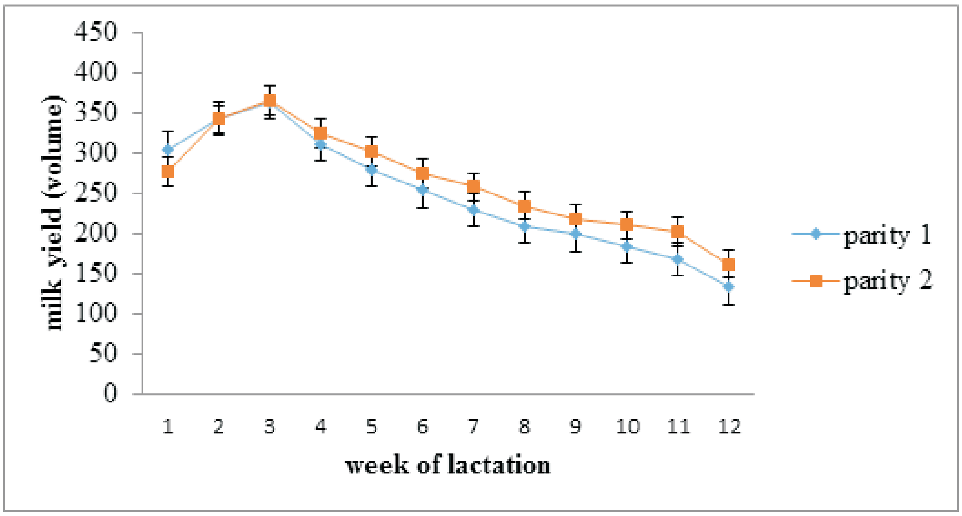

Figure 3. Lactation curve of WAD goats of different parities

Table 3: Shows Means and standard errors of the effects of oxytocin, litter size and parity on parameters of lactation curve of WAD goats

Factors	a (volume)	B	c
Oxytocin doses			
1	285.68 ± 17.86^{b}	0.64 ± 0.04^{a}	0.21 ± 0.01
2	391.73 ± 12.27^{a}	0.27 ± 0.04^{b}	0.16 ± 0.03
3	396.80 ± 19.91^{a}	0.36 ± 0.04^{b}	8.15 ± 7.99
Litter size			
1	340.97 ± 14.38^{b}	0.46 ± 0.04^{a}	4.18 ± 3.99
2	410.04 ± 18.34^{a}	0.31 ± 0.06^{b}	0.15 ± 0.02
Parity			
1	374.71 ± 12.67^{a}	0.40 ± 0.04	4.49 ± 4.30
2	337.51 ± 26.08^{b}	0.44 ± 0.07	0.15 ± 0.01

$^{a-b}$ For each variable, means in the column having different superscript differ significantly ($p < 0.05$).

Effects of oxytocin on lactation curve characteristics of WAD goats

The means of lactation curve characteristics of WAD goats injected with exogenous oxytocin is shown in Table 4. The results showed that oxytocin affected lactation curve characteristics R^2, PW and PY (P < 0.05) but had no significant effect on PSS (Table 4). 4 IU and 2 IU oxytocin were the same for "R^2" but differed significantly (P < 0.05) from R^2 of 0 IU (Table 4). 4 IU and 2 IU oxytocin were the same for "*PW*", but differed from the "*PW" of 0 IU* (Table 4). Oxytocin doses of 4 IU, 2 IU and 0 IU were the same for "*PY*" (Table 4). *This showed that both does injected with oxytocin and the does not injected had the similar PY.* Oxytocin 4 IU and 2 IU were significantly (P < 0.05) the same for "R^2" characteristics, but differed significantly (P < 0.05) from the R^2 characteristics of 0 IU (Table 4). The coefficient of determination (R^2), which provides information on the model's fit on the available data, was 1.00 ± .001and 0.99 ± .001 for 4 IU and 2 IU doses of oxytocin respectively and 0.99 ± .002 for 0 IU. Wood's equation fitted well the lactation curves of different oxytocin dose with R^2 of 100%, 99% and 99% for 4 IU, 2 IU and 0 IU respectively. Marete *et al. (2014) reported that Wood's equation fitted well the lactation curves of the different genetic groups with R^2 values ranging from 85% to 91% in Alpine goats.* The result showed that oxytocin doses 4 IU and 2 IU were significantly (P < 0.05) the same for "*PW*" characteristics of lactation curve, but differed significantly (P < 0.05) from the "*PW"* characteristics of the control (Table 4). *"PW" of* 4 IU and 2 IU *occurred early compared with the "PW" of 0 IU. Therefore, it indicated that the time to reach maximum weekly milk yield decreased with injection oxytocin.* The result showed that oxytocin doses 4 IU, 2 IU and T0 were significantly (P < 0.05) the same for "*PY*" (Table 4). *This showed that both does injected with oxytocin and the does not injected has the same peak milk yield.*

Effect of litter size (single or twins) on lactation curve characteristics

Table 3 shows the means effects of litter size on lactation curve characteristics of WAD does. *Litter size* (single or twin suckled kids) significantly affected (P < 0.05) PW and PY but had no significant effect on R^2 and PSS (Table 4). The results (Table 4) showed that PW of does with single kid differed significantly (P < 0.05) from PW of does with twin kids. The PW of does with single kid was higher compared with PW of does with twin kids. The results (Table 4) showed that PY of does with twin kids differed significantly (P < 0.05) from does with single kid. The PY of does increased with increasing litter size. *Litter size* (single or twin suckled kids) significantly affected (P < 0.05) Peak week (PW) and Peak yield (PY) but had no significant effect on R^2 and on PSS (Table 4). This is result is in agreement with report of Hamed (2010) who reported that PW was significantly influenced by kidding type. The result is also agrees with the report of *Ayasrah et al. (2013) who reported a significant effect of litter size on PW of Damascus goats.* The result of PW was in agreement with that reported by (Rojo-Rubio *et al*., 2016) for Alpine, Saanen and Anglo-Nubian goats. Does suckled by twin kids had lower PW than does suckled by single kid. Rojo-Rubio *et al*. (2016) observed that goats with twin kids had less time of peak which indicated higher milk production per day and thus a higher total lactation than does with a single kid. The result (Table 4) showed that PY increased with increasing litter size. Sánchez *et al*. (2006) reported a significant effect of litter size on the total milk production and daily production. The result disagreed with the report of Marete *et al*. (2014) who observed non-significant effect of litter size on PY. The result also disagreed with the report of *Ayasrah et al. (2013) who* *recorded* non-significant effect of litter size on PY. The more litter size the more frequently milk is evacuated from the alveoli, this in turn will influence the number and activities of the secretory cells (Li *et al.,* 1999).

Effect of parity on lactation curve characteristics

Table 4 shows the means effects of parity on lactation curve characteristics of WAD does. . Parity ($P < 0.05$) significantly affected PW but had no significant effect on R^2, PY and Pss (Table 4). The results showed that PW of does in second parity differed significantly ($P < 0.05$) from that of does in first parity. The does in second parity experience PW of lactation later than the does in first parity. The result showed that does in second parity experienced peak week of lactation later than the does in first parity. This result is not in agreement with report of Waheed and Kahn (2013), who observed non-significant effect of parity on the time of PY. Ayasrah *et al.* (2013) also observed a non significant effect of parity on PW. The result agreed with report of Montaldo *et al.* (1997) on crossed goat in Mexico, who observed a significant influence of parity on the time required to attain peak yield.

Table 4. Shows means and standard errors showing the effects of oxytocin, litter size and parity on lactation curve characteristics of WAD goats

Factors	Coefficient of determination(R^2) (%)	PeakWeek (PW)	Peak Yield (PY) (volume/Week)	Persistency (PSS)
Oxytocin doses				
1	$0.99 \pm .002^b$	3.09 ± 0.20^a	304.87 ± 8.87^a	2.56 ± 1.93
2	$0.99 \pm .001^a$	1.78 ± 0.17^b	355.73 ± 12.58^a	2.45 ± 0.13
3	$1.00 \pm .001^a$	2.11 ± 0.19^b	355.66 ± 27.75^a	1.93 ± 0.61
Litter size				
1	$0.99 \pm .001$	2.46 ± 0.16^a	322.14 ± 14.42^b	2.21 ± 0.31
2	$0.99 \pm .002$	1.90 ± 0.22^b	383.16 ± 9.80^a	2.53 ± 0.06
Parity				
1	$0.99 \pm .001$	2.10 ± 0.14^b	337.35 ± 15.44	2.08 ± 0.33
2	$0.99 \pm .002$	2.63 ± 0.28^a	346.19 ± 15.80	2.71 ± 0.04

[a-b] For each variable, means in the column having different superscript differ significantly ($p < 0.05$).

Conclusion

WAD goats curve parameter showed that WAD goats had smaller initial milk yield 'a' with high "b" and "c". This indicated that period of lactation in WAD goats is short. Persistency of lactation in WAD goats was low, thus, the ability of WAD does to maintain milk production throughout the lactation period was low. The findings revealed that oxytocin, litter size and parity had noticeable influence on "a", "b" and "c", peak week, peak yield, persistency of milk. Oxytocin injected does and does with twin kids had higher initial milk yield 'a' but lower 'b', thus the tendency of extending lactation period.

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