Journal of Animal and Veterinary Advances 9 (1): 79-84, 2010
ISSN: 1680-5593

Effect of Restricted Suckling on Body Weight, Body Condition Score and Onset of Postpartum Ovarian Activity in F1 Cows under Tropical Conditions

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Abstract: The objective of this study was to determine the effect of the suckling systems on live body weight, body condition score and the onset of the postpartum ovarian activity in *Bos taurus* x *Bos indicus* cows under tropical humid conditions of Mexico. Sixty multiparous pregnant *B. taurus* x *B. indicus* cows, with average age and body weight of 6.38±2.4 years and 446.8±58.7 kg, respectively, were used. Cows were randomly assigned to two treatments: Continuous Suckling (CS; n = 30), the calves remained with the cows for 24 h daily; Restricted Suckling (RS; n = 30), the calves suckled once a day by 30 min, starting on the 7th day of the postpartum period until day 105. There was not significant effect of the suckling system on body weight and luteal phase duration ($p>0.05$). However, differences ($p<0.02$) were found for body condition score (3.01±0.06 vs. 3.33±0.06, for CS and RS, respectively). The ovulation rate was higher ($p<0.001$) in the RS group that in the CS (83.3 vs. 36.6%, respectively) and the interval calving-first ovulation was shorter ($p<0.005$) for the RS (58.7±6.2 days) than for the CS system (84.6±6.2 days). Pregnancy rate at 45 days postpartum was higher ($p<0.001$) in the RS system (50.0%), with regard to the CS group (13.3%). Under the present conditions of this study, the suckling system affected the body condition score, ovulation rate and conception rate of *B. taurus* x *B. indicus* cows.

Key words: Cattle, *Bos taurus* x *Bos indicus*, calving to ovulation interval, body condition, restricted suckling, tropics

INTRODUCTION

Meat production in tropical regions relies mainly on Zebu cattle and their crosses with *Bos taurus* cattle; however, reproductive efficiency of livestock in these regions is poor, not only because of genetic limitations but also because the effect of the environmental conditions characterized by very intense droughts periods, along with systems of continuous grazing in paddocks with low availability of nutrients or dry matter and little or no food supplement, which are the main factors that affect the nutritional balance (Perez *et al*., 2001).

Low intake of nutrients can cause a negative energy balance associated with mobilization of body reserves designed to maintain milk production, which leads to an accentuated body weight loss in the post-partum, which seems to prolong anestrous (Kawashima *et al*., 2008). This seems to be the main problem affecting the reproductive efficiency of production units and that causes major economic losses for producers (Ahmed, 2007). According to Plasse (1994), under extensive conditions, plant biomass production per unit area seems not to be enough to fill the needs of pregnant cows especially if they are first calving cows, due to the demands of this physiological status for maintenance, growth, milk production and reproduction.

The implementation of a restricted mating period to 90 days year^{-1} involves modifying the cow-calf management to get the maximum benefit from this reproductive practice. The inhibitory effect of suckling on the onset of reproductive activity is widely known in the

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beef cattle industry (Short *et al*., 1972; Radford *et al*., 1978; Wettemann *et al*., 1978; Berardinelli *et al*., 2005), particularly in Zebu type cattle. The objective of this study was further to contribute to determine the effect of type of suckling on body weight, body score and onset of postpartum ovarian activity in *Bos taurus* x *Bos indicus* cows under the tropical-humid conditions of Mexico.

MATERIALS AND METHODS

Localization of the area of study: The experiment was conducted in the Tabasco campus of the Colegio de Postgraduados located in Cardenas Tabasco, Mexico at 18°00' North latitude and 93°30' West longitude and 9 m above sea level. The climate of the region is hot and humid with 2.231 mm average annual rainfall and average annual temperature of 26.1°C (Garcia, 1988).

Animals and treatments: Sixty *B. taurus* x *B. indicus* multiparous pregnant cows of unknown breed grade, with mean age and weight of 6.38±2.4 years and 446.8±58.7 kg, respectively, were used. The cows were randomly distributed to treatments as they were calving: Group 1, included cows with calf at foot under Continuous Suckling (CS, n = 30) and group 2, included restricted suckling cows (cows to which calves were withdrew at 7 days postpartum for about 30 min daily in the morning (AR, n = 30). All cows were kept in star grass (*Cynodon plectostachius)* paddocks with native grass (*Paspalum* sp.) and water *ad-libitum*.

Cow body weight and score: Cows were weighed and their body condition score was measured at 14 days interval, from calving to 120 days postpartum. Cows body condition was determined by visual appraisal of the lumbar vertebrae and the bottom of the tail, using a 1-5 scale, where 1 = emaciated and 5 = obese (Rossi, 2006).

Blood sampling: At day seven postpartum blood samples were taken from all the cows, jugular vein punction, twice a week (monday and friday) until day 105 postpartum. Blood samples were centrifuged (1800x g at -4°C) to obtain the sera and kept at -20°C, until progesterone testing (P_4) using solid phase Radioimmunoassay (Coat A Count, Diagnostics Products Corporation), with a sensitivity of 20.1 ng mL^{-1} and an interassay coefficient of variation of 3.93%.

Ovarian activity definition: When P_4 concentration was >1 ng mL^{-1} the cow onset of ovarian activity was confirmed (Stevenson and Britt, 1979). The luteal phase was considered of normal duration (>7 days) if P_4 concentration was >1 ng mL^{-1} in three consecutive sampling moments (Kawashima *et al*., 2007).

Estrous detection, time of service and conception rate: Estrous was detected by visual appraisal twice a day (am and pm) by space of 60 min, registering the hour and date of estrous. Females in heat were served by artificial insemination 12 h after estrous detection. The conception rate was determinate by rectal palpation 45 days after artificial insemination.

Statistical analysis: Data on body weight and body condition of cows were analyzed by repeated measure models, using the MIXED procedure of SAS (2000) considering the animal as the experimental error term to determine the effect of the type of suckling system. Ovulation rate, luteal phase duration of the corpus luteum and pregnancy rate at 45 days was analyzed by χ^2-tests. The variable days at first ovulation postpartum was analyzed using a t-test (JMP, 2002).

RESULTS AND DISCUSSION

Pospartum body weight: No significant effect of suckling system was observed ($p>0.05$) on body weight change during the postpartum period (434.0±2.97 vs. 439.8±2.95) for CS and RS, respectively. The cows body weight for the two suckling systems decreased from the onset of lactation until the 16th postpartum day. The RS cows increased their body weight from day 23 till 56, whereas the CS cows maintained their body weight loss until day 56 and tend to decrease slightly until, day 105 (Fig. 1). At calving time, the mean cow body weight was 453.2+10.3 and 448.8±10.3 kg for the CS and RS groups, respectively. At 105 days the mean body weights were 429.2±10.3 and 438.9±10.6 kg, respectively. The CS cows decreased 24 kg on average and those of the RS group 10 kg.

It is possible that the body weight loss observed during the 16 first postpartum days in both groups of cows has been due to the fact that the nutritional requirements for the onset of the lactation are higher

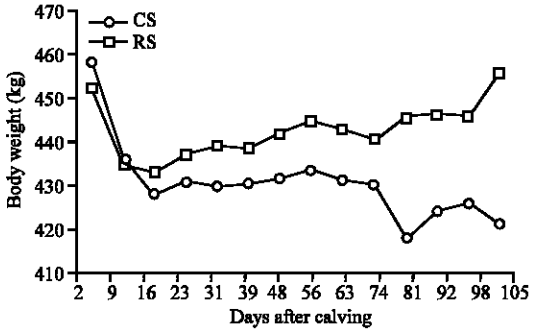

Fig. 1: Postpartum body weight of F1 cows under Restricted (RS) and Continuous Suckling (CS) under tropical condition of Mexico

than those provided by the grass paddocks (Ramirez-Iglesias *et al*., 1992). The RS cows probably decreased their fodder consumption, because of the stress they were subject from day 7 after calving, when they were separated from their calves. Nevertheless, on day 23 they adapted to the 30 min daily suckling and entered to a phase of positive energy balance and they gained weight. For the CS cows their weight loss was more pronounced, as result of having the calf at foot and had to produce more milk, which might cause a greater mobilization of the cow body reserves. Similar results were found by Villa-Godoy and Villagomez (2000) in cows grazing in Star grass during the first 120 days after calving. Weight loss during the suckling period has been reported by Salgado *et al*. (2005), who found a difference of 37 and 38 kg between calving weight and weight at the end of the study for cows suckled by the calf twice a day for 30 min or with a calf at foot for 7-8 h day^{-1}. This suggests that cows increase their metabolism and achieve a greater mobilization of their body reserves to meet the needs of the calf. The environmental conditions of the tropics characterized by periods of very intense drought, along with continuous grazing systems, with few grass availability and quality, low availability of dry matter or nutrients and no food supplement, since to constitute the main factors that affect the nutritional balance. Low intake of nutrients causes a negative energy balance associated with a mobilization of the body reserves designed to maintain milk yield, which induces a marked loss of weight in the postpartum (Perez *et al*., 2001).

Postpartum body condition: Differences between the two types of suckling system ($p<0.02$) in body condition score were observed. Starting the second postpartum day a decrease ($p<0.05$) in body condition of the CS cows was found. The RS cows maintained they body condition score from 9-48 day postpartum, increased it from 56-81 day and decreased from 92-105 day postpartum (Fig. 2). A linear relationship have been reported between

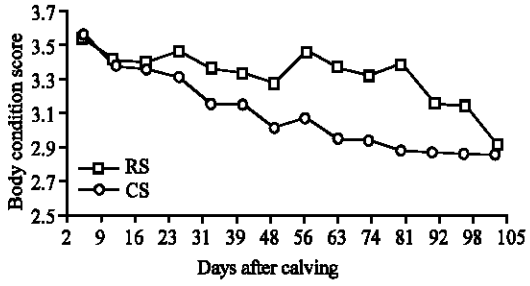

Fig. 2: Postpartum body condition score of F1 cows under Restricted (RS) and Continuous Suckling (CS) under tropical condition of Mexico

body condition score and body weight, indicating that for each unit change of body condition is associated with a change of 33 (Lalman *et al*., 1997), 38 (Wagner *et al*., 1988) or 40 kg (Buskirk *et al*., 1992) of live weight (using a scale of 1-9). In this study, using a 1-5 scale, the results agree with the previous reports, being observed that for each half-point of body condition reduction, 22 kg body weight reduction. NRC (1996) assumes that 44 kg weight is associated with one unit of body condition score using two linear functions that converge to a score of 5 points.

There is evidence that the body condition at calving has an important effect on the onset of the ovarian activity. In this study, cows started with an average body condition score of 3.5 (on a scale of 1-5) at calving and after 120 days their score fell to 2.87±0.11 for CS and 2.92±0.11, for RS; both groups decreased slightly >0.5 point. For an optimal reproduction Short *et al*. (1990), recommended a body condition score of 5-7 before calving (on a 9 points scale) because it is very difficult and expensive to correct nutritional problems by increasing food consumption after calving. Salgado *et al*. (2005) noted that the type of suckling system causes an increase in the mobilization of body reserves and a loss of up to one point in the corporal condition in cows undergoing suckling twice per day for about 30 min, or under a traditional system, where the calves stayed with their mother continuously for a period of 6 or 7 h.

Nutrient requirements increase substantially after calving and during the lactation peak, which is usually reached between the 45-60 days of postpartum. In addition, the reproductive functions must be restarted in order to maintain a birth per year, therefore a lactating cow fed base only on grass, may not consume the nutrients to meet their demands for maintenance and milk production. In this regard, Salgado *et al*. (2005) found that supplementation during the early postpartum does not prevent the loss of body condition, whereas the cow fed the calf and they reported a loss of 1.1 and 0.9 points in body condition in cows supplemented (2.5 kg cottonseed) and not supplemented, during the post-partum period. The loss of body condition has been associated with the mobilization of the body reserves, being the non-esterifies fatty acids one of the metabolites, which can act as early indicators of the use of the body reserves. Kawashiwa *et al*. (2008) reported an increase in the serum concentration of non-esterified fatty acids in cows subjected to suckling than those cows, which were not subjected to that management.

According to Plasse (1994), under extensive conditions, production of plant biomass per unit area seems to be not enough to fill the needs of a lactating cow and even more if they are first calving cows, due to the

Table 1: Onset of the ovarian activity, interval-calving to first ovulation and conception rate of *B. taurus* x *B. indicus* cows with Continuous (CS) or Restricted Suckling (RS) under tropical conditions of Mexico

	Ovulating cows			Interval calving first ovulation	Luteal phase duration n (%)		Pregnancy at 45 days postpartum	
Groups	N	n	%	(days)	≤7 days	≥14 days	n	%
CS	30	11	36.6[a]	84.6±6.2[a]	8 (72.7)	3 (27.2)	4	13.3[a]
RS	30	25	83.3[b]	58.7±6.2[b]	6 (54.5)	5 (45.4)	15	50.0[b]
p-values	-	-	p<0.001	p<0.005	-	-	-	p<0.001

demands that this physiological status demands for maintenance, growth, milk production and reproduction, therefore, the body condition decrease, as a result of a poor nutrition, increasing the time required to the onset of luteal activity (Bishop *et al*., 1994).

Onset of ovarian activity: The system of suckling effected (p<0.001) the onset of ovarian activity. Ovulation and conception rates were higher for the RS system than for the CS system. The number of days at first ovulation was lower for the RS system (p<0.005). There was no difference (p>0.05) in the luteal phase duration of the corpus luteum of RS and CS cows (Table 1).

Effect of type of suckling effect was also observed by Stagg *et al*. (1998), who found that the interval calving to first ovulation in Holstein cows and their crosses with Hereford and Angus under continuous suckling re-initiated ovarian activity 79 days after calving, whereas those cows subject to restricted suckling with the calf near or isolated presented means of 62 and 51 days, respectively.

Among the factors that affect cow reproduction, suckling and nutrition occupy an important role. Galina and Arthur (1989) indicate that suckling is an external stimulus in the regulation of reproductive cycles of meat type cows and that the presence of the calf can delay the onset of the hypothalamus pituitary activity. Sacoto *et al*. (2005) reported a calving to first ovulation interval greater in cows subjected to continuous suckling (75 day) than those subjected to restricted suckling (45 day) or milking (31 day), additionally, those researchers reported that the first estrous was noted at 93, 70 and 49 days, respectively. Marin *et al*. (2007) observed that in dairy cows with calf removed at 7 days of age, the onset of ovarian activity was shown at 29.6±12.4 days, achieving a reduction this period by the supplementation of polyunsaturated fatty acids in the diet (23.3±12.8), possibly because vegetable oil provides highly available energy for the reactivation of the hypothalamus pituitary gonads axis, the LH preovulatory peak, ovulation and functional development of the corpus luteum.

Apart from the effects of suckling and nutrition on reproduction, some researchers report interaction between variables. An inadequate nutrition increases the time of calving to first estrous induced by suckling in beef cows (Butler and Smith, 1989; Stagg *et al*., 1998). The physiological mechanisms by which undernourishment and loss weight cause the prolongation of the anestrous postpartum are little known. However, the failure in ovarian activity is attributed to a deficiency in gonadotropins causing alterations in the follicular development, absence of estrous and lack of ovulation (Perez *et al*., 2001; Ahmed, 2007; Kawashima *et al*., 2008). Robson *et al*. (2008) pointed out that if the onset of ovarian activity occurs shortly after calving, this only is accompanied by follicular development because the first dominant follicle can be detected at 10-20 days postpartum. However, ovulation does not occur because in this period there is a low serum concentration of LH (Stagg *et al*., 1998), as result of a negative feedback of estrogen together with endogenous opioid peptides and negative energy balance, which limits the input of energy for the hormone synthesis (Williams, 1990). In this regard, the low frequency of LH, pulses observed during the postpartum (Kawashiwa *et al*., 2008) would cause the atresia of dominant follicles. Other researchers have pointed out that suckling and the constant presence of the calf decrease the hypothalamic release of the Gonadotropin Releasing Hormone (GnRH) and LH, extending the time of the onset of the ovarian activity. It has been shown that the removal of the calf increases the release of GnRH (Gazal *et al*., 1998) and therefore, the frequency and amplitude of LH pulses (Griffith and Williams, 1996; Yawas and Walton, 2000).

Some studies show that an increase in the intake of nutrients after calving increases the conception and pregnancy rates in meat-producing cows (Wiltbank *et al*., 1962). Raising the energy density in the diet increases the body weight and the body condition, reducing the calving to first estrous interval. However, few cows fed a diet of high energy start estrous at 90 days postpartum.

Similarly, nursing cows supplemented with a concentrated to win >1 kg day^{-1} do not start ovarian activity before 70 days postpartum (Lalman *et al*., 1997). Browning *et al*. (1994) noted that the onset of the ovarian activity in cows under continuous suckling, the calving to first estrous interval was 64.6±3.9 day, while for cows under restricted suckling was 41.9±3.0 day. These researchers also found that the percentage of cows that started ovarian activity was 70 vs. 16%, when suckling was restricted or continuous, respectively.

CONCLUSION

The suckling system affected the body condition, ovulation rate, interval calving to first ovulation and pregnancy rate of *Bos taurus* x *Bos indicus* cows under tropical-humid conditions of Mexico.

REFERENCES

Ahmed, W.M., 2007. Overview on some factors negatively affecting ovarian activity in large farm animals. Global Vet., 1: 53-67.

Berardinelli, J.G., P.S. Joshi and S.A. Tauck, 2005. Postpartum resumption of ovarian cycling activity in first-calf suckled beef cows exposed to familiar or unfamiliar bulls. Anim. Reprod. Sci., 90: 201-209. PMID: 16298271.

Bishop, D.K., R.P. Wettemann and L.J. Spicer, 1994. Body energy reserves influence the onset of luteal activity after early weaning of beef cows. J. Anim. Sci., 72: 2703-2708. PMID: 7883630.

Browning, R. Jr., B.S. Robert, A.W. Lewis, D.A. Neuendorff and R.D. Randel, 1994. Effects of postpartum nutrition and once-daily suckling on reproductive efficiency and preweaning calf performance in fall-calving Brahman (*Bos indicus*) cows. J. Anim. Sci., 72: 984-989. PMID: 8014166.

Buskirk, D.D., R.P. Lemenager and L.A. Horstman, 1992. Estimation of Net Energy requirements (NEm and NEA) of lactating beef cows. J. Anim. Sci., 70: 3867-3876. PMID: 1474025.

Butler, W.R. and R.D. Smith, 1989. Interrelationships between energy balance and postpartum reproductive function in dairy cattle. J. Dairy Sci., 72: 767-783. PMID: 2654227.

Galina, C.S. and G.H. Arthur, 1989. Review of cattle reproduction in the tropics. Part 3. Puerperium. Anim. Breed. Abstr., 57: 899-910.

Garcia, E., 1988. Modificaciones al Sistema de Clasificacion Climatica de Köopen. 4th Edn. Instituto de Geografia, UNAM, Mexico, pp: 194.

Gazal, O.S., L.S. Leshin, R.L. Stanko, M.G. Thomas, D.H. Keisler, L.L. Anderson and G.L. Williams, 1998. Gonadotropin-Releasing hormone secretion into third-ventricle cerebrospinal fluid of cattle: Correspondence with the tonic and surge release of luteinizing hormone and its tonic inhibition by suckling and Neuropeptide. Y. Biol. Reprod., 59: 676-683. PMID: 9716569.

Griffith, M.K. and G.L. Williams, 1996. Roles of maternal vision and olfaction in suckling-mediated inhibition of luteinizing hormone secretion, expression of maternal selectivity and lactational performance of beef cows. Biol. Reprod., 54: 761-768. PMID: 8924494.

JMP, 2002. User Guide: Statistic. Version 5.2.1. Statistical Analysis System Institute Inc. Cary, North Caroline, USA.

Kawashima, C.H., K. Kida, K.G. Hayasi, M.C. Amaya, E. Kaneko, N. Matsunaga, T. Shimizu, M. Matsui, Y.I. Miyake and A. Miyamoto, 2007. Changes in plasma metabolic hormone concentrations during the ovarian cycles of the Japanese black and holstein cattle. J. Reprod. Dev., 53: 247-254. PMID: 17132912.

Kawashima, Ch., K. Kida, M. Matsuhasi, M. Matsui, T. Shimizu, N. Matsunaga, M. Ishii, Y. Miyake and A. Miyamoto, 2008. Effect of suckling on the reproductive performance and metabolic status of obese Japanese black cattle during the early postpartum period. J. Reprod. Dev., 54: 46-51. PMID: 17998776.

Lalman, D.L., D.H. Keisler, J.E. Williams, E.J. Scholljegerdes and D.M. Mallet, 1997. Influence of postpartum weight and body condition change on duration of anestrus by undernourished suckled beef heifers. J. Anim. Sci., 75: 2003-2008. PMID: 9263044.

Marin, M.A., J.C. Tinoco, J. Herrera, L.G. Sanchez, V.M. Sanchez, J.L. Solorio and V.A. Garcia, 2007. Reinicio de la actividad ovarica y nivel de metabolitos de lipidos en vacas lecheras suplementadas con aceite vegetal durante el posparto temprano. Interciencia, 32: 180-184. http://www.interciencia.org/v32_03/180. pdf.

National Research Council (NRC), 1996. Nutrient Requirements of Beef Cattle. 7th Edn. National Academy Press, Washington, D.C.

Perez, H.P., R.C. Sanchez and S.J. Gallegos, 2001. Anestro posparto y alternativas de manejo del amamantamiento en vacas de doble proposito en el tropico. Inv. Agric. Prod. Sanid. Anim., 16: 257-270. http://www.inia.es/gcontrec/pub/perez_1161096003796.pdf.

Plasse, D., 1994. Factores Que Influyen en la Eficiencia Reproductiva de Bovinos de Carne en America Latina Tropical y Estrategias Para Mejorarla. En: Seminario Internacional de Manejo de la Reproduccion Bovina. Cartagena, Colombia. CIPEC, pp: 82-120.

Radford, H.M., C.D. Nancarrow and P.E. Mattner, 1978. Ovarian function in suckling and non-suckling beef cows postpartum. J. Reprod. Fert., 54: 93-100. PMID: 712712.

Ramirez-Iglesias, L., E. Soto-Belloso, C. Gonzalez-Stagnaro, G. Soto-Castillo and E. Rincon-Urdaneta, 1992. Factors affecting postpartum ovarian activity in crossbred primiparous tropical heifers. Theriogenology, 38: 449-460. PMID: 16727147.

Robson, C., J.F. Aller, S. Callejas and R.H. Alberio, 2008. Dinamica folicular posparto y comportamiento del amamantamiento en razas Angus y criolla Argentina. Archivos de Zootecnia, 57: 477-488.

Rossi, J., 2006. Body condition scoring beef cows. The University of Georgia College of Agricultural and Environmental Sciences. Bulletin, 1308: 1-12.

Sacoto, S., J.C. Almeida and V.C. Alves, 2005. Postpartum anestrus in suckled beef cows influence of live weight and body condition score on resumption of ovarian activity. Reprod. Dom. Anim., 40: 400.

Salgado, O.R., S.L. Torregroza and P.J. Alvarez, 2005. Amamantamiento restringido y suplementacion de semilla de algodon sobre el peso y condicion corporal en vacas bajo sistema de produccion doble proposito. MVZ-Cordoba, 10: 663-672.

SAS, 2000. SAS User's Guide. Statistics. SAS Institute Inc. Cary, North Caroline, USA.

Short, R.E., R.A. Bellows, R.B. Staigmiller, J.G. Berardinelli and E.E. Custer, 1990. Physiological mechanisms controlling anestrous and fertility in postpartum beef cattle. J. Anim. Sci., 68: 799-816. PMID: 2180877.

Short, R.E., R.A. Bellows and E.L. Moody, 1972. Effects of suckling and mastectomy on bovine postpartum reproduction. J. Anim. Sci., 34: 70-74. PMID: 5059174.

Stagg, K., L.J. Spicer, J.M. Sreenan, J.F. Roche and M.G. Diskin, 1998. Effect of calf isolation on follicular wave dynamics, gonadotropin and metabolic hormone changes and interval to first ovulation in beef cows fed either of two energy levels postpartum. Biol. Reprod., 59: 777-783. PMID: 9746725.

Stevenson, J.S. and J.H. Britt, 1979. Relationships among luteinizing hormone, estradiol, progesterone, glucocorticoids, milk yield, body weight and postpartum ovarian activity in Hosltein cows. J. Anim. Sci., 48: 570-577. PMID: 528417.

Villa-Godoy, A. and A. Villagomez, 2000. Influencia de la dieta y el amamantamiento en el balance energetico, la condicion corporal, la produccion lactea, el metabolismo y el desempeño reproductivo en vacas de doble proposito. En: Curso Internacional de Reproduccion Bovina. UNAM, Mexico, pp: 167-215.

Wagner, J.J., K.S. Lusby, J.W. Oltjen, J. Rakestraw, R.P. Wettemann and L.E. Walters, 1988. Carcass composition in mature Hereford cows: Estimation and effect on daily metabolizable energy requirement during winter. J. Anim. Sci., 66: 603-612.

Wettemann, R.P., E.J. Turman, R.D. Wyatt and R. Totusek, 1978. Influence of suckling intensity on reproductive performance of range cows. J. Anim. Sci., 47: 342-346.

Williams, G.L., 1990. Suckling as a regulator of postpartum rebreeding in cattle: A review. J. Anim. Sci., 68: 831-852. PMID: 2180879.

Wiltbank, J.N., W.W. Rowden, J.E. Gregory and R.M. Koch, 1962. Effect of energy level on reproductive phenomena of mature Hereford cows. J. Anim. Sci., 21: 219-225.

Yawas, Y. and J.S. Walton, 2000. Postpartum acyclity in suckled beef cows. A review. Theriogenology 54: 25-55. PMID: 10990346.