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Effect of Maternal Feeding in Late Pregnancy on Behaviour and Performance of Egyptian Goat and Sheep and Their Offspring

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Abstract: This study was conducted on 40 pregnant Egyptian Baladi does and ewes, with the aim of investigating the effect of maternal plan of nutrition at late pregnancy on maternal and neonatal behaviour and productive performance of both dams and offspring. At the last six weeks of gestation, animals were randomly assigned to two nutritional planes for each species (10 does or ewes/group). The control and treated groups were fed with total mixed rations supplying 100% and 135% of the NRC requirements respectively. These groups were the same for both species. Grooming and sucking behaviours, dam's body weight, rectal temperature of offspring, birth weight and body weight at 8 weeks of age were recorded. Blood samples were taken for serum chemical analysis. The results revealed that well feeding (sheep and goats) during last stage of pregnancy significantly improved dam's body weight ($P<0.05$), kid's rectal temperature ($P<0.01$), lamb's birth weight ($P<0.05$) and weaning weight of both kids and lambs ($P<0.05$). Additionally, dams fed high level of concentrates spent more time grooming their offspring and were more cooperative with the suckling behaviour of their offspring ($P<0.05$). Lambs born to well fed ewes had higher serum total protein ($P<0.01$) and globulin ($P<0.05$) than those born to control ones. It was concluded that increasing concentrate mixture during late pregnancy improves birth weight; immunity and reduces the incidence of hypothermia.

Key words: Concentrate · Does · Ewes · Behaviour · Performance

INTRODUCTION

The survival of small ruminant's newborn in the first hours following birth is influenced by many factors including dam nutrition during pregnancy [1, 2], process of birth [3], maternal behaviour [4], neonatal behavior [5] and the physical environment at which parturition occur [6]. The proper development of fetuses and newborn (lambs and kids) requires an adequate transport of nutrients across the placenta and mammary gland. Approximately two-third of the birth weight of a developing fetus is gained during the last six weeks of gestation. Therefore, balanced nutrition during late gestation is crucial for fetal development and survival at birth [7]. The challenge in feeding pregnant ewes is to provide adequate energy and protein to support embryonic and fetal growth, maintenance of metabolic processes, mammary gland growth, colostrum and milk yield [8, 9]. Moreover, nutritional supplementation during fetal life affects fetal ovarian development [10], postnatal growth [11], reproductive performance [12] and metabolism [13]. Consequently, suboptimal nutrition can negatively affect birth weight [14-17] and early postnatal growth [18, 19]. Also it retard the growth of mammary secretary tissue mass [20, 21] that will affect on lactation period leading to reduced colostrum and/or milk availability for the offspring and affecting growth and lamb survival to weaning [17, 22- 24]. On contrary, lambs born from high feed allowance ewes had higher rectal temperatures at birth than lambs born from low fed ewes [25]. When multiple bearing ewes were offered additional feed in late pregnancy, lamb mortality was reduced for single and twin lambs [26].

In small ruminants, survival and welfare of newborn depend on the rapid development of a reciprocal mother–young bond [27]. Maternal under nutrition may also impair lamb survival by affecting the appropriate expression of maternal and neonate behaviors at birth

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associated with ewe–lamb bonding and constitute an important cause of lamb death [1, 27]. Undernourished ewes took longer to attend to their lambs, cleaning and allowing them to suck than in well fed ewes [28]. Neonate survival is dependent on the coordinated expression of appropriate behavioral patterns in both the dam and offspring to ensure that the young is adequately fed and nurtured [29, 30]. Consequently, the maternal behaviour of the dam has been shown to be a major factor in neonate survival [31], where the dam plays an important role in the behavioural interactions that occur between ewe and their offspring during the first few hours following birth and ultimately ends in the suckling behaviour [4]. This work was carried out to investigate the effect of nutritional supplementation of sheep and goats during last stage of pregnancy on maternal and neonatal behavioural and some productive performance of both dams and offspring.

MATERIALS AND METHODS

This study was carried out at the farm of faculty of veterinary medicine, sadat branch, Menoufia university during the period between 2012 and 2013.

Animals and Management: Forty Egyptian Baladi goats and ewes were used in this experiment. Average body weight was 29.63 kg and average age was 3.8 years for goats. Ewe's body weight and age were 38.38 Kg and 2.0 years in average respectively. Estrus was synchronized by using intravaginal sponges containing 20 mg fluorogestone acetate (FGA) (Chronogest ®, Intervet, Boxmeer, Holland) that was inserted intravaginal for 14 days and 17 days in sheep and goats respectively. This was followed by intramuscular injection of 400 IU of PSMG (Folligon, Intervet International, Boxmeer, Holland) per animal after sponge removal. The ewes and does were naturally mated with rams and bucks of the same breed at the second day of sponge removal. Pregnancy diagnosis was recorded by ultrasonic scanning at 64-70 day for doe and 30-45 day for ewes after breeding.

In the last six weeks of gestation, animals were randomly assigned to two nutritional planes for each species (10 does or ewes/group). The control and treated groups were fed with total mixed rations supplying 100% and 135% of the NRC [32] requirements respectively. These groups were the same for both species. The concentrate composed of 2% fat, 14% protein, 15% fiber, 12% moisture. The animals had free access to mineral blocks and water. Does and ewes were vaccinated against clostridia with 2 ml subcutaneous injection of clostridia vaccine (Ultrabac® 8, Pifizer Animal Health Technical services, Canada) at last 2 month of pregnancy followed by second dose after 45 days. Two weeks before parturition animals were moved to large straw bedded pens (720x440 cm) in order to allow animals to adapt to presence of observer, pregnant animals were regularly checked for signs of parturition.

Table 1: Description of maternal behaviors according to Pickup and Dwyer [33].

Behaviour	Definition
Grooming	Licking or nibbling lamb, or chewing the remnants of foetal membranes.
Circling	As the lamb attempts to reach udder, ewe moves her hind-quarters away from the lamb.
Backing	As the lamb attempts to reach udder, ewe moves backwards.
Forward	As the lamb attempts to reach udder, ewe moves forward.

Data Collection

Behavioural Observations: Recording system including DVR and video cameras (Sony, Japan) covers lambing pen area to record maternal (grooming) and neonatal (sucking) behaviour. All offspring were identified to their dams, their sex and birth rank. Each dam and their offspring were observed in two days in the first week after parturition (at the first and third days of birth). Behavioural observations were carried out in two periods per day (two hrs each). The first period was in the beginning of the day and the second one was at the end of the day to determine the degree of relationship between dam and their offspring through observation of grooming and some rejection behaviour exhibited by the dam as described by Pickup and Dwyer [33] (Table 1).

Suckling behaviour duration showed by offspring was recorded when kid or lamb holds teat in its mouth and appears to be sucking with appropriate mouth and head movements, may be tail-wagging, remains in this position for >5s as described by Dwyer *et al*. [5].

Dam and Offspring Performance: All dams were weighed before starting the treatment. The birth weight of newborns and their rectal temperature were recorded using clinical thermometers (Mercury thermometers, China) pre-suckling. The weight of dam was recorded 2 hrs after birth. To minimize the disruption to mother and offspring bonding, all samples were collected within the lambing pen, which allowed the mother to continue interact with their young during sampling and the sample was collected within few minutes of entering the pen. The body temperature recording were repeated at 24 h and 72 h of birth. Offspring were weighed again at 8 week of age. Blood samples were collected from all goats and ewes before and after parturition and from their offspring after birth. Samples were centrifuged 3000 rpm for 20 minutes. The obtained sera were separated and stored at –20°C until analysis for serum glucose, total protein and albumin concentration by spectrophotometer (Spekol 11, Carl Zeiss Jena, Germany) according to the instructions of manufacture (Diagnostic diamond, Egypt) [34]. The concentration of globulin was calculated as the difference between serum total protein and albumin.

Statistical Analysis: Collected data were statistically analysed using Statistical Package for Social Sciences (SPSS version 10). Data of treated and control groups for both dam and offspring were analyzed using independent t-test. Weight of dam before and after treatment as well as glucose concentration of the same before and after parturition was tested using the self pairing t-test. Results expressed as the Means ± S.E.

RESULTS AND DISCUSSION

Our results indicated that pregnant dam (sheep or goat) supplemented with high level of concentrate (135%) during last six weeks of pregnancy had significantly higher body weight compared to non supplemented dam (P=0.01, P=0.04, respectively for sheep and goat) (Table 2). Also, the weight of concentrate supplemented dams (goat and sheep) was significantly ($P<0.05$) increased after supplementation with high level of concentrate compared to their weights before supplementation. This result was in close agreement with Dwyer [1] who reported that ewes supplemented with high level of concentrate were heavier than other ewes that supplemented with low level of concentrate. Also, Meyer *et al.* [35] found that ewe body weight differed because of nutritional plane (60% restricted, 100% control and 140 % high from day 40 of gestation till parturition). Weight of restricted ewes was less than weight of control and weight of high nutritional ewes was greater than control one. Similar results were reported by Kerslake *et al*. [36]. In the same trend, Laporte-Broux *et al.* [37] reported that restricted goats (70% of energy) between 90 d of pregnancy and parturition was lost 8.2% of body weight than control goats fed ad-libitum.

Feeding of high level of concentrate had a better effect on birth weight and weaning weight of offspring particularly lambs (Table 3). Lambs born from highly nurished ewes were heavier at birth and at 8 weeks of age than those born from control ones. In the same time, kid body weight was improved significantly at 8 weeks of age in goat's group supplemented with concentrate if compared with control one. Similar results previously reported that maternal nutrition during late gestation resulted in improved colostrum and/or milk availability for the offspring, therefore affecting growth and lamb survival to weaning.[17,22- 24]. Also maternal nutritional restriction during pregnancy caused a significant reduction in mean lamb birth-weight by 9% when compared with well-fed ewes [1]. In addition, Kerslake *et al.* [36] reported that offering 400 gm/day for pregnant ewes at day 102 until day 145 of pregnancy resulted in decrease in metabolic stress and an increase in birth weight of offspring. However, during the last 2 weeks of pregnancy, particularly in twin- or triple-bearing ewes; voluntary feed intake declines [38] although the higher demand for nutrients [8]. The last 6 weeks of gestation in goats and ewes are a critical period for the pregnant animal because about 80% of the foetal growth occurs during this period. During late gestation, the abdominal space is filled with accumulated fat and an over-expanding uterus. Therefore, the multiple-bearing animals have difficulty consuming enough feedstuff to satisfy their energy requirements because of reducing of rumen space [39]. Hence it has been suggested that offering concentrate during late stage of pregnancy increased the total nutrient intake especially in twin and triplet bearing ewes [36].

Kids born from well fed goats had significantly higher pre-suckling rectal temperature ($P<0.01$) compared to kids produced from control ones. Also, lambs born from well fed ewes had high rectal temperature at the first day after birth but this difference did not reach to significant value (P=0.28). This result was in accordance with Moore, Millar and Lynch [25] and Hight and Jury [40] who reported that lambs born to ewes fed well had higher rectal temperatures at birth and are better equipped to survive.

Maternal nutrition during pregnancy may affect the expression of maternal behaviour. Low fed ewes and cows had higher plasma progesterone concentrations over the last third of gestation in comparison with the well fed animals [41-44]. Low feed intake is also associated with a delay in the postpartum decline in plasma progesterone [45]. Maternal behaviour is induced by the central release of oxytocin [46, 47]. In sheep, both progesterone and oestrogen promote the synthesis of oxytocin mRNA in areas of the brain implicated in maternal behaviour [48]. In sheep and rats, high oestradiol [49-51] and a high oestradiol: progesterone value [49, 51] in late gestation is correlated with the expression of maternal behaviour.

Table 2: Effect of supplementation of high concentrate at late pregnancy on body weight of goats and ewes before supplementation and after parturition (M±SE)

	Goats			Ewes		
Body weight (kg)	High concentrate (135%)	Control (100%)	*P*- value	High concentrate (135%)	Control (100%)	*P*- value
Before supplementation	30.31±1.74 [B]	27.40±2.17	0.33	40.18±1.93 [B]	35.20±0.36	0.09
After parturition	33.09±0.65 [aA]	27.63±2.16 [b]	0.01	41.73±1.91 [aA]	35.78±0.36 [b]	0.04
P-value	0.04	0.06		0.02	0.36	

[a,b]Means within the same row within the same species.

[A,B]Means within the same column within the same species.

Table 3: Effect of supplementation of high concentrate at late pregnancy on body weight and rectal temperature of kids and lambs (M±SE)

	Kids			Lambs		
	High concentrate (135%)	Control (100%)	*P*- value	High concentrate (135%)	Control (100%)	*P*- value
			Body weight (kg)			
At birth	2.51±0.09	2.01±0.27	0.13	3.57±0.16[a]	2.72±0.21[b]	0.02
At 8 weeks	8.63±1.35[a]	5.77±0.56[b]	0.05	10.56±1.02[a]	7.25±0.69[b]	0.05
			Rectal temperature (°C)			
At birth	39.3±0.08[a]	38.7±0.06[b]	0.01	39.5±0.10	39.1±0.54	0. 28
At 24 h	39.3±0.27	39.2±0.22	0.67	39.1±0.17	39.1±0.47	0.86
At 72 h	39.2±0.20	39.0±0.26	0.55	38.9±0.17	39.0±0.50	0.86

Table 4: Effect of supplementation of high concentrate at late pregnancy on doe and ewe maternal and kid and lamb neonatal behaviour (M± SE)

	First period			Second period		
	High concentrate (135%)	Control (100%)	*P*- value	High concentrate (135%)	Control (100%)	*P*- value
			Doe maternal behaviour			
Grooming (sec)	360.00±30.41[a]	107.00±8.45[b]	0.05	167.33±23.68	93.00±17.49	0.24
Forward (frequency)	0.00±0.00	0.60±0.04	0.30	1.00±.01	0.40±0.04	0.53
Circling (frequency)	0.00±0.00	1.00±0.07	0.37	0.00±0.00	0.20±0.02	0.48
Backing (frequency)	0.00±0.00	0.20±0.02	0.48	0.00±0.00	0.00±0.00	
			Kid neonatal behaviour			
Sucking (min)	15.56±3.55 [a]	3.76±1.56 [b]	0.01	16.14±4.94 [a]	4.52±1.73 [b]	0.05
			Ewe maternal behaviour			
Grooming (sec)	147.00±6.92 [a]	16.25±1.75 [b]	0.04	89.61±6.77	73.25±3.52	0.74
Forward (frequency)	1.60±0.07	0.00±0.00	0.10	0.80±0.06	0.00±0.00	0.26
Circling (frequency)	0.00±0.00	1.40±0.06	0.20	0.00±0.00	1.40±0.05	0.14
Backing (frequency)	0.00±0.00	0.00±0.00		0.00±0.00	0.00±0.00	
			Lamb neonatal behaviour			
Sucking (min)	10.05±1.58 [a]	2.81±.18 [b]	0.01	9.73±2.61 [a]	1.76±0.48 [b]	0.04

The effects of under nutrition in elevating plasma progesterone in late gestation and reducing the oestradiol: progesterone value may be responsible for differences in maternal behaviour between the low fed and well fed ewes. Also, low fed ewes may have motivated to eat, as spent more time eating after the birth of their lambs than high fed ewes. In addition to the direct effects of under nutrition on maternal care, there were several effects of nutrition level on the parturition process that have responses correlated with reduced expression of maternal care. Lambs born from low fed ewes were more likely to be mal presented than lambs born from well fed ewes and tended to require more intervention to be delivered and this also related to reduced total grooming attention in ewes [28, 52].

Data summarized in Tables (4) indicated that kids and lambs born to well fed dams (goat or sheep) with high level of concentrate (135%) exhibited significantly more suckling behaviour during the first week after birth And spent significantly more time (P=0.05) licking and grooming their offspring (kids and lambs) (Tables 4). There were no marked difference in rejection behaviours of dams (such as forward, circling and backing) between concentrate supplemented and non supplemented groups. Our results were in agreement with Dwyer [1] who reported that well fed ewes spent significantly more grooming the lamb than low fed ewes and there was no effect of treatment group on the number of ewes performing any lamb rejection behaviours, or frequency that these behaviours were expressed. This may be indicated that inadequate bond formation between the ewe and her lambs was owing to low grooming behaviour. However, suckling and milk ingestion play a fundamental role in lamb bonding to the ewe [53] and in the maintenance of maternal behaviour [54]. Therefore, high milk production in the well fed ewes may influence the quality of the relationship formed by the lamb to the ewe and interfere with the maintenance of maternal behavior.

Lamb birth weight had a significant effect on the latency to perform nearly all neonatal behaviors. In general, low-birth-weight lambs had a slower progression to standing and sucking than heavier lambs. In addition to their slower development, low-birth-weight lambs appeared to lack co-ordination or the ability to accomplish successful sucking when compared with heavier lambs [1]. Additionally, under nutrition impairs both vigor and the ability to carry out complex behaviours [55]. Therefore, maternal under nutrition may have harmful effect on the development and complexity of brain structures, leading to reductions in cell numbers and myelination of axons [56-57]. Thus, under nutrition during gestation had an indirect effect on the early expression of neonatal lamb behaviours as well as effects on lamb birth-weight. In the current study, birth weights of kids and lambs born to nutritionally supplemented dam were higher than birth weights of kids and lambs born to control dam, (Table 3). Therefore maternal nutritional supplementation during late stage of pregnancy improved both neonatal and maternal behaviours. On the other hand, Hight and Jury [40] reported that, the effect of lamb birth weight on lamb behaviour is inconclusive and it is highly likely that a complex of physiological and genetic factors underpin lamb behaviour, not including the effect of maternal behaviour.

In this study serum glucose level after parturition was not significantly differed between dams (sheep or goats) supplemented with high level of concentrates compared to control non supplemented dams (sheep or goats) (Table 5). This may be attributed to increased glucose mobilization during late stage of pregnancy as blood glucose level in pregnant animals is generally low, because of fetal demand. Adult ruminant obtain very little glucose from its diet and its metabolic requirements for glucose are supplied by gluconeogenesis in the liver and kidney [60]. Studies in sheep have shown that they synthesize about 100 g of glucose a day, but during late pregnancy this basal rate can go up to about 180 g/ day [61]. The requirements for glucose considerably increase in the pregnant animal and the fetus and the uterus utilize glucose as a major of energy source [62]. The energy requirements of the pregnant goat increase by a factor of 1.5 when she carries one foetus and by a factor of 2 when she carries two foeti [39]. Maternal glucose is the primary source of fuel for feotal and placental tissues [63] and consequentlyMaternal under nutrition leads to maternal hypoglycaemia, reduced uterine and umbilical uptakes of glucose, reduced placental glucose transfer capacity [64].

Table 5: Effect of supplementation of high concentrate at late pregnancy on serum glucose (mg/dl) level for dam and offspring after parturition (M ± E).

	Goat			Sheep		
	High concentrate (135%)	Control (100%)	*P*- value	High concentrate (135%)	Control (100%)	*P*- value
Dam	52.723±3.72	57.090±10.38	0.65	60.65±4.94	73.618±12.87	0. 28
Offspring	109.04±5.63	100.98±3.62	0.25	132.93±8.54	113.72±8.41	0.58

Table 6: Effect of supplementation of high concentrate at late pregnancy on serum total protein, albumin and globulin in kids and lambs (M ± SE).

	Kid			Lamb		
	High concentrate (135%)	Control (100%)	*P*- value	High concentrate (135%)	Control (100%)	*P*- value
Total protein (g/dl)	8.29±1.073	8.30±0.77	0.99	6.39±0.15[a]	4.98±0.05[b]	0. 01
Albumin (g/dl)	1.58±0.10	1.93±0.18	0.10	1.96±0.19	1.50±0.08	0.12
Globulin (g/dl)	6.71±1.02	6.37±0.82	0.80	4.43±0.26[a]	3.48±0.05[b]	0.03

The current study showed little variation in serum glucose levels in Kid's and lamb'sborn to well fed and low fed mothers (Table 6). The lack of differences could be attributed to consumption of glucose to generate body temperature. As exposure to cold results in increased mobilization of glucose and free fatty acids to be used in thermogenic process 65]. This notation was confirmed by our results in Table (3), as birth rectal temperature was higher in offspring born from well fed dams compared to control offspring.

Results from Table (6) revealed that nutritional supplementation of goat during late pregnancy had no significant effect (P>0.05) on kids serum total protein, albumin and globulin. While lamb born to well fed ewes had significantly higher serum total protein (P<0.01) and globulin (P<0.05) than lambs born to control ewes. No information is available about the possible differences in the immune response of both ruminant species due to different feeding plan. These findings were in accordance with Hashemi, Zamiri and Safdarian [66] who reported that ewes fed on the diet of 110% NRC produced significantly more colostrum than did the ewes in control group. This result may be attributed to enhance colostrum production that considered the main source of immunoglobulin for neonates [67, 68]. In addition, maternal nutrition affecting immunoglobulin-G (IgG) concentrations in the colostrum [44, 69] and there was a positive relationship between feeding regimes, colostrum production and IgG transfer.

CONCLUSION

In conclusion, nutritional supplementation of small ruminants during last stage of pregnancy improved dam body weight and strengthen the mother young relationship. In addition, offspring birth weight, rectal temperature; neonatal behaviour as well as weaning weight were enhanced the things are beneficial to immunity particularly in lambs.

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