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Performance and maternal-offspring behavior of ewes fed protected fat from palm oil

Desempenho e comportamento materno-filial de ovelhas alimentadas com gordura protegida de óleo de palma

Guilherme Batista dos Santos[1*]; Renata Negri[2]; Emilyn Midori Maeda[3]; Valter Oshiro Vilela[3]; João Ari Gualberto Hill[4]; Vicente de Paulo Macedo[3]

Highlights:
Great demand to improve the reproductive efficiency of sheep.
Use of fatty acids in the diet to increase energy density.
Productive and reproductive improvements.

Abstract

This study aimed to evaluate the performance and maternal-offspring behavior of ewes fed protected fat from palm oil. Forty multiparous ewes with an average age of three years were divided into two treatments, with or without protected fat supplementation (in concentrate). Every 15 days and at the time of lambing, weighing and body condition evaluation of sheep were performed, while lambs were evaluated at birth until weaning. Duration of post-weaning anestrus was obtained through the manifestation of estrus, detected by a vasectomized male. Data were submitted to analysis of variance. No difference was observed between supplementations for body weight, body condition score, and average daily gain during the gestation phase. Ewes fed protected fat had a superiority regarding the body score during the lactation phase. Lambs from ewes supplemented with protected fat were weaned faster, and ewes presented an early estrus. No difference was observed between treatments for maternal-offspring behavior. The use of fat during lactation showed improvement in productive (body condition score) and reproductive (shorter anestrus period) parameters. It also reduces the weaning age of lambs and does not alter maternal-offspring behavior.
Key words: Average daily gain. Gestation. Lactation. Post-weaning anestrus. Saponified fatty acids.

Resumo

O objetivo foi avaliar o desempenho e comportamento materno-filial de ovelhas alimentadas com gordura protegida de óleo de palma. Foram utilizadas 40 ovelhas multíparas com idade média de três anos divididas em dois tratamentos, com ou sem suplementação de gordura protegida (no concentrado). A cada 15 dias e no momento do parto, foram realizadas pesagens e avaliação da condição corporal

[1] Discente do Curso de Mestrado do Programa de Pós-Graduação em Zootecnia, Universidade Tecnológica Federal do Paraná, UTFPR, Dois Vizinhos, PR, Brasil. E-mail: guilherme_bs@yahoo.com.br
[2] Discente do Curso de Doutorado do Programa de Pós-Graduação em Zootecnia, Universidade Federal do Rio Grande do Sul, UFRGS, Porto Alegre, RS, Brasil. E-mail: rn.negri@yahoo.com
[3] Profs., Curso de Zootecnia, Universidade Tecnológica Federal do Paraná, UTFPR, Dois Vizinhos, PR, Brasil. E-mail: emilyn@utfpr.edu.br; valter@utfpr.edu.br; vicentepmacedo@utfpr.edu.br
[4] Pesquisador, Instituto Agronômico do Paraná, IAPAR, Pato Branco, PR, Brasil. E-mail: joaohill@iapar.br
[*] Author for correspondence

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das ovelhas, enquanto os cordeiros foram avaliados no nascimento até o desmame. A duração do anestro pós-desmame foi obtida através da manifestação do estro, detectada por macho vasectomizado. Os dados foram submetidos à análise de variância. Verificou-se que na fase de gestação não houve diferença entre as suplementações, para peso vivo, escore de condição corporal e ganho médio diário. Na fase de lactação observa-se superioridade das ovelhas que receberam gordura protegida, no escore corporal. Cordeiros filhos de ovelhas suplementadas com gordura protegida foram desmamados mais rápidos e as ovelhas apresentaram cio mais cedo. Não houve diferença entre os tratamentos para o comportamento materno-filial. O uso da gordura durante a lactação apresentou melhoras em parâmetros produtivo (escore de condição corporal) e reprodutivo (menor período de anestro). Além de reduzir a idade de desmama dos cordeiros e não alterar o comportamento materno-filial.
Palavras-chave: Ácidos graxos saponificados. Anestro pós-desmame. Ganho médio diário. Gestação. Lactação.

Introduction

Brazil has great potential for sheep meat production, but the country has faced a worrying scenario, which consists of a herd with poor productive performance associated with a disorganized production chain and weak links. Sheep breeders have been charged for animal reproductive efficiency, either by increasing twin gestations and/or decreasing lambing intervals (Silva, 2008).

According to Grandinson (2005), inadequate sheep nutrition, especially at the final third of gestation, can compromise lamb development in the pre-and postnatal period and alter the female reproductive cycle. As pregnant ewes have their physical ingestion capacity reduced due to fetal development (Petit, 2003), nutritional intake and improved reproductive indices can be reached by fat supplementation, which increases dietary energy density. In addition to nutritional support, Church and Dwight (2002) stated that certain amounts of essential fatty acids are required for prostaglandin synthesis (acting on ovulation and conception) and progesterone regulation (acting to maintain gestation). Therefore, this study aimed to evaluate the effect of protected fat from palm oil of ewe gestation and lactation, and the maternal-offspring behavior.

Material and Methods

The experiment was carried out at the sheep and goat teaching and research unit of the Federal Technological University of Paraná (UTFPR), campus of Dois Vizinhos, located in southwestern Paraná, with a latitude of 25°41′35″ S and longitude of 53°05′30″ W-GR (Instituto Nacional de Meteorologia [INMET], 2015). The regional climate is classified as Cfa, i.e., a mesothermal humid subtropical climate with an average precipitation of 1953 mm and annual maximum and minimum averages temperatures of 25.2 and 14.7 °C, respectively (Alvares, Stape, Sentelhas, Gonçalves, & Sparovek, 2013).

The experiment was developed respecting ethical principles in animal experimentation determined by the Ethics Committee on Animal Use, as the protocol requirement No. 2015-07. The experiment was carried out from July to October 2015. Forty multiparous F1 Santa Inês and Dorper ewes with an average of three years of age, mated with Dorper rams, were kept on Aruana grass (*Panicum maximum*) pasture and fed isoproteic and isoenergetic concentrate with 13% crude protein and 4.5 Mcal kg^{-1} of metabolizable energy (Table 1), being offered 1% body weight based on dry matter. The ewes were separated in two treatments, with and without supplementation of protected fat from palm oil, during gestation and lactation, being 20 ewes in each treatment. Each ewe consumed an average of 130 grams per 100 kg body weight (LW) per day of protected fat in the treatment of protected fat concentrate.

Ewes with ultrasound-confirmed pregnancy (only one lambs, disregarding twins) began the experimental period at the time they reached 100 days of gestation after a 15-day adaptation. Supplementation was completed at 30 days of lactation. During this period, ewes were routed daily to the Aruana grass pasture at 8h00 and removed at 17h30 to remain stabled at night in a suspended slatted floor containing collective stalls. The facility had mineral supplement and drinking troughs. The concentrate was supplied in feeding troughs in the collective stalls at 17h45.

Table 1
Composition of experimental concentrates

Ingredients	Treatments	
	Without fat	With fat
Ground corn, % DM	86.80	70.00
Soybean meal, % DM	13.20	16.60
Protected fat*, % DM	0.00	13.40
Total	100.00	100.00
Chemical composition (%)		
Crude protein (CP)	12.96	13.07
Metabolizable energy (ME, Mcal kg^{-1})**	4.50	4.50

* Calcium soap (palm oil) with 84% solid fat that provides 44% palmitic acid.
** Calculated on the basis of the National Research Council [NRC] (2007).

Animals were weighed and body condition was evaluated according to Russel, Doney and Gunn (1969) by palpation of the lumbar region and assigning values from 1 (very thin) to 5 (very fat) ± 0.25. Subsequently, the animals were weighed after a 12-14-hour fasting every 15 days and evaluated for body condition score.

Measurement of birth weight was performed after the first feeding to avoid interfering with the behavior of the ewe with the lamb. Behavioral assessments were performed directly, with instantaneous recording and focal sampling (Martin & Bateson, 1986). Follow-up was started from the complete expulsion of the fetus, registering the time of calving and the time (minutes) that the lamb took to stand, time from birth to first feeding, and time from birth to the total expulsion of the placenta by the ewe.

After lambing, ewes remained with the lambs for 7 days, receiving corn silage *ad libitum* and its respective amount of daily supplement concentrate. After this time, ewe and lamb returned daily to the pasture. The supply of concentrate was suspended after 30 days of lactation and ewes and their lambs were confined receiving corn silage ad libitum, with access to mineral supplement and water. This management was performed until the time lambs reached a weight of 17 kg for weaning.

After weaning, ewes were re-driven to the Aruana pasture. In order to measure the post-weaning anestrus, the manifestation of estrus was detected by a vasectomized male, whose sternum region was stained with a mixture of colored powder and vegetable oil to identify the breed until the first manifestation of estrus.

Six paddocks of Aruana pasture, two of them with 1,000 m^2 and the other four with 3,000 m^2, were used. The fertilization of the experimental area was carried out at each grazing exit with 100 kg N ha^{-1}, totaling 140 kg N during the experimental period. Forage mass (FM) was determined by the double sampling technique (Wilm, Costello, & Klipple,

1944) at each entrance and exit of animals. Pasture, silage, and concentrate samples were analyzed at the Laboratory of Food Analysis of UTFPR, campus of Dois Vizinhos, to determine crude protein by the Kjeldahl method (Association of Official Analytical Chemists International [AOAC], 1995), as well as neutral detergent fiber (NDF) and acid detergent fiber (ADF) as modified by Komarek (1993) in the methodology of Robertson and Van Soest (1981). The ethereal extract (EE) contents of these samples were obtained according to the method adapted for the Gerhardt Soxtherm apparatus, following the methodology of the Instituto Adolfo Lutz [IAL] (2008) (Table 2).

Table 2
Average values in percent dry matter (DM), crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), ether extract (EE) and mineral matter (MM) of the foods used in the research

Item	DM	CP	NDF	ADF	EE	MM
Aruana grass, %	27.12	15.54	70.99	34.16	3.10	9.94
Corn silage, %	26.92	9.11	53.65	24.23	2.24	3.25
Without fat concentrate, %	90.86	12.96	22.90	3.00	2.45	1.96
With fat concentrate, %	92.08	13.07	28.00	8.00	19.67	10.88

Forage supply (kg DM 100 kg^{-1} LW) was calculated by dividing the daily forage availability (average FM of the period + forage production of the period/number of days) by the average animal load in the grazing period, multiplied by 100. Forage production was monitored during the experimental period, reaching an average forage mass of 1,663 DM kg ha^{-1} and an average forage supply of 6.01 kg DM 100 kg^{-1} LW.

The experimental design was completely randomized. The statistical model adopted was $Y_{ij} = \mu + \tau_i + \varepsilon_{ij}$, where Y_{ij} is the observed value of variable Y in individual j receiving treatment i, μ is the general constant, τ_i is the effect of supplementation i, where i = concentrate with or without protected fat, and ε_{ij} is the random error associated with each observation. The results were submitted to analysis of variance at 5% significance level and residual normality test (Shapiro). Analyses were performed by the program R (R Development Core Team [R], 2013).

Results and Discussion

No difference (P>0.05) was observed between treatments during gestation for body weight, body condition score, and average daily gain (Table 3). Supplementation may assist in the final third of gestation as energy support, a period in which there is a decrease in physical space due to fetal growth, then leading to a reduction in dry matter intake. Such weight gain is generally not closely linked to ewe body mass gain but to greater and improved fetal development.

Table 3
Estimated average for body weight (kg), body condition score (ECC, points), average daily gain (kg) during gestation, standard deviation and general average for ewes supplemented with concentrate containing protected fat and without fat

Variables	Treatments		Overall average
	Without fat	With fat	
Body weight 100 days of gestation [ns]	59.35 ± 11.59	60.38 ± 8.20	59.86
Body weight 115 days of gestation [ns]	62.13 ± 12.26	61.83 ± 8.76	61.98
Body weight 130 days of gestation [ns]	63.94 ± 11.84	65.93 ± 9.66	64.93
Body weight 145 days of gestation [ns]	64.81 ± 12.16	66.70 ± 9.76	65.75
ECC 100 days of gestation [ns]	3.31 ± 0.43	3.29 ± 0.25	3.30
ECC 115 days of gestation [ns]	3.55 ± 0.54	3.55 ± 0.40	3.55
ECC 130 days of gestation [ns]	3.5 ± 0.71	3.82 ± 0.48	3.66
Average daily gain [ns]	0.12 ± 0.11	0.14 ± 0.12	0.13

[ns] No significant difference (P>0.05).

The average live weight didn't differ (P>0.05) in the lactation phase (Table 4). Santos, Godoy, Sousa, Assis and Sena (2017) also observed no difference in live weight of Santa Inês sheep supplemented or not with protected fat and stated that sheep supplementation during lactation allowed maintaining body weight in the postpartum, as a result of correct feeding management.

Table 4
Estimated average for body weight (kg), body condition score (ECC, points) and average daily gain (kg) of ewes during lactation, age of lambs at weaning (days), days of post-weaning anestrus, standard deviation and general average for ewes supplemented with concentrate containing protected fat and without fat

Variables	Treatments		Overall average
	Without fat	With fat	
Ewes weight at lambing[ns]	57.04 ± 8.93	62.62 ± 6.97	59.83
Body weight 15 days of lactation [ns]	55.21 ± 10.17	60.53 ± 6.22	57.87
Body weight 30 days of lactation [ns]	54.06 ± 10.00	60.81 ± 6.42	55.99
Weaning weight [ns]	51.63 ± 10.46	57.93 ± 7.90	54.78
ECC at lambing [1]	3.06 ± 0.29	3.43 ± 0.31	3.24
ECC 15 days of lactation [1]	2.75 ± 0.32	3.26 ± 0.25	3.00
ECC 30 days of lactation [1]	2.83 ± 0.36	3.27 ± 0.26	3.05
ECC weaning [1]	2.74 ± 0.37	3.04 ± 0.26	2.89
Average daily gain [ns]	-0.09 ± 0.07	-0.10 ± 0.08	-0.50
Age of lamb to weaning [1]	64.53 ± 6.42	49.57 ± 10.18	57.05
Days of post-weaning anestrus [1]	15.70 ± 5.57	10.3 ± 3.09	13.00

[ns] No significant difference (P>0.05); [1] significant difference (P<0.05).

Body condition score values showed a difference (P<0.05), with superiority in animals that received protected fat. It may be due to a phase in which the demand for nutrients is high for milk production and ewes maintenance, reaffirming the need not only for supplementation but also for the use of an adequate food strategy. Ribeiro, Fontana, Wald, Gregory and Mattos (2003) monitored sheep in the 60-days breeding period and observed that animals with body condition score between 3.0 and 4.0 points had a gestation rate of 93.96% when compared to those with body condition between 2.0 and 2.5 points, which had a gestation rate of 86%, thus showing the importance of a good body condition at weaning and respectively at the beginning of the breeding season.

The total daily average gain in the lactation phase showed no difference (P>0.05) between treatments. However, negative gains may come from an energy deficit linked to an increase in milk production. According to Araújo et al. (2008), it may occur in lactating ewes due to the difficulty of supplying nutrients by feeding inadequate amounts in this phase because energy demand increases faster than dry matter intake.

The variable age of lamb to weaning showed a difference (P<0.05). Ewes that didn't receive fat in the diet weaned lambs with 64.53 days, while those that received fat in the diet weaned their lambs at 49.57 days of age. That is, lambs reached the weaning weight of 17 kg, 15 days before the group of lambs from ewes that didn't receive fat in the diet, presenting a considerable advantage of 23% at weaning time.

A difference (P<0.05) was observed for the variable days of post-weaning anestrus, which was lower in ewes that received protected fat, showing estrus 10.30 days after weaning, unlike those that didn't receive fat and took 15.70 days to manifest estrus. However, when the days to estrus are added to the age at weaning, an average positive balance of 20 days is obtained for ewes receiving fat when compared to those not receiving. That is, ewes are more productive within the production cycle, weaning the lamb in a shorter time and presenting heat faster than the ewes that didn't receive fat in the diet. When these results are projected in an average production cycle of four years for each ewe, we will have, on average, seven births for ewes that received protected fat, unlike those that didn't receive it, which would only have six births at the same production cycle. Thus, a 15% increase in production over the same period. This result differs from that obtained by Costa et al. (2011), who supplemented 30 g of protected fat per individual per day for Santa Inês sheep and didn't obtain a decrease in postpartum anestrus.

No difference (P<0.05) was observed for maternal-offspring behavior between treatments (Table 5). The time taken for the lamb to stand was, on average, 16.42 minutes, which was better than the results obtained by Queiroz (2018), who observed an average of 78.77 minutes for Santa Inês lambs to stand. The results obtained by Dwyer (2003) demonstrated that the time taken by Scottish Blackface and Suffolk lambs to stand after calving was on average 30 minutes, which is similar to the results described by Moraes et al. (2016), who observed an average time of 26.13 minutes for Corriedale lambs.

Table 5
Values in minutes (min) of time taken by lamb to stand after birth, time from birth to first suckling, time from birth to placental release in sheep, standard deviation and overall mean of lambs for ewes that received supplementation with or without fat protected in gestation

Variables	Treatments		Overall average
	Without fat	With fat	
Time taken by lamb to stand after birth [ns]	17.26 ± 11.09	15.58 ± 8.57	16.42
Time from birth to first suckling [ns]	33.26 ± 15.18	34.05 ± 11.16	33.65
Time from birth to placental release [ns]	250.80 ± 50.77	237.94 ± 70.94	244.37

[ns] No significant difference (P>0.05).

No difference (P>0.05) was observed from birth to first feeding. The average obtained was 33.65 minutes, which is considered positive for the productive life of these animals since one of the critical phases is the first hours of life after birth. In this case, the rectal temperature of a lamb falls from 1 to 2 °C in relation to that in the uterine environment (39 °C), i.e., the faster the lamb accomplish nursing, the greater the chances of survival. According to Dwyer, Lawrence and Bishop (2001), the first suckling is of vital importance for lamb survival and development since it is at this time that nutrient and immunity, such as immunoglobulins, are provided through ingestion of colostrum. Queiroz (2018) obtained an average of 166.92 minutes spent until the first feeding of field-born lambs, thus increasing the chances of unsuccessful survival. Dwyer and Lawrence (1998) worked with wool sheep and obtained from 73 to 119 minutes for the first feeding, and stated that rapid access to colostrum is of utmost importance for the survival of lambs born with limited reserve tissues.

Measurement of time from birth to placental release showed no difference (P>0.05), in which ewe had an average total time of 244.37 minutes for total expulsion. A characteristic that may influence this total time of placental expulsion is the body structure, which is inherent to the distension of the pelvic region, i.e., pluriparous females have greater ease in the expulsion of the fetus and, consequently, placenta (Grandinson, 2005). A longer time to release may be due to the physiological action of oxytocin, as it is known that the peak release of this hormone occurs at delivery and decreases to a lower rate over time, and it results in a longer time for placental expulsion.

No difference (P>0.05) was observed between treatments for lamb weight from birth to weaning, and the use of ruminally inert fat from palm oil didn't interfere with lamb production (Table 6). The same was true for body condition score of lambs, which showed no difference (P>0.05) between treatments. Similarly, Espinosa, López-Molina, Ramírez-Godínez, Jiménez and Flores (1998) evaluated the effect of protected fat on the feeding of lactating sheep and didn't observe any difference in lamb performance. Moreover, Bona et al. (1994) worked calcium salts from fatty acids at different levels in postpartum sheep and their offspring and verified no difference (P>0.05) for the average daily gain. These results corroborate those described by Costa et al. (2011), who observed that Santa Inês lambs from ewes supplemented with protected fat didn't obtain differentiation in performance when compared to lambs from sheep that didn't receive fat.

Table 6
Estimated averages from birth to weaning for characteristics of body weight (kg), average daily gain (kg), body condition score (ECC, points) and standard deviation of lambs son of ewes that were supplemented or not whit protected fat

Treatments	Body weight [ns]				
	Birth	15 days	30 days	Weaning	Overall average
Without fat	3.84 ± 1.04	8.32 ± 1.64	11.67 ± 2.31	17.47 ± 2.81	-
With fat	4.08 ± 0.95	8.81 ± 1.82	12.86 ± 2.53	17.46 ± 3.03	-
	Average daily gain [ns]				
Without fat	-	0.298 ± 0.06	0.225 ± 0.08	0.200 ± 0.07	0.240
With fat	-	0.317 ± 0.07	0.270 ± 0.07	0.186 ± 0.08	0.250
	Body condition score [ns]				
Without fat	1.85 ± 0.42	3.20 ± 0.33	3.32 ± 0.45	3.27 ± 0.95	-
With fat	1.88 ± 0.31	3.29 ± 0.40	3.43 ± 0.43	3.26 ± 0.93	-

[ns] No significant difference (P>0.05).

Conclusion

Ewes fed protected fat during lactation showed improvements in productive (body condition score) and reproductive (shorter anestrus period) parameters. In addition to promoting the reduction in the weaning age of lambs.

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