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Effect of *Acacia albida* Leaf Supplementation on Reproductive Parameters and Pre-Weaning Growth of Arabian Lambs

Oumar Moucthar Kodbe[1,2*], Miegoue Emile[1], Mouchili Mama[1], Azoutane Julien[3], Ousmane Issa Abdel Djalil[4], Kwayep Nyah Cedric[1], Taboumda Evariste[1], Tendonkeng Fernand[1]

[1]Animal Nutrition Laboratory, Animal Production Department, FASA, University of Dschang, Dschang, Cameroon
[2]Biology Laboratory of the Faculty of Exact and Applied Sciences (FSEA), Uinversity of N'Djamena, N'Djamena, Chad
[3]University of Sciences and Technology of Ati (USTA), Ati, Chad
[4]National Higher Institute of Sciences and Techniques of Abéché (INSTA), Abéché, Chad
Email: *omarkodbe@gmail.com

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Abstract

A trial on *Acacia albida* leaf supplementation on reproductive parameters and pre-weaning growth of Arabian lambs was conducted from September 2020 to May 2021 at the small ruminant station of the Livestock Research Institute for Development (IRED) in N'Djamena, Chad. Forty-eight (48) Arabian sheep (45 non-pregnant females and 3 males for a sex ratio of 1 ram to 15 ewes) with an average weight of 20.3 ± 1.2 kg and aged approximately 2 years were divided into 3 groups of 15 ewes each. The supplemented group received in addition to the dominant forage of the pasture (300 g of *Dactyloctenium aegyptium* + 300 g of *Cenchrus ciliaris* + 600 g of *Panicum maximum*), 400 g and 600 g of *Acacia albida* leaves/animal/day while the control group received only 300 g of *Dactyloctenium aegyptium* + 300 g of *Cenchrus ciliaris* + 600 g of *Panicum maximum*. From the results of this study, it appears that the ewes that received 400 g of *Acacia albida* leaves had a significantly higher fertility rate and birth mortality rate (93.03% and 6.25% respectively). Animals in the control group had a significantly higher pre-weaning mortality rate than those receiving *Acacia albida* leaves as a supplement (16.66% versus 6.66% and 14.28% respectively). The highest weight of the lambs was observed in the ration supplemented with 600 g of *Acacia albida* leaves (12209.66 g). The total weight gain, as well as the average daily weight gain of the lambs receiving the 600 g *Acacia albida* leaf ration was significantly higher than those of the other rations. Supplementation with 400 g and 600 g of *Acacia albida* leaves can be recommended as a protein supplement for breeding ewes and pre-weaned lambs.

Keywords

Acacia albida, Lamb, Growth, Weaning, Supplementation

1. Introduction

Feeding is one of the major challenges to livestock development, as feed insufficiency is one of the factors that lead to a decline in the reproductive performance of animals, resulting in considerable economic losses [1]. This loss is higher during the dry season because during this period, ruminant feeding is mainly based on the use of crop residues on the one hand [2] [3] and the mobility of animals in search of forage in the Sudanian zone on the other hand [4]. Despite the strength of the animals in the face of the agro-ecological conditions of sub-Saharan Africa, there is a decline in productivity due to the high lamb mortality rate varying between 20% and 48% [5]. Most of these mortalities are due to insufficient mother's milk, refusal of the ewe to suckle her young or vulnerability of the lamb at parturition [6]. According to Toukourou *et al.* [7], to achieve better growth performance of young lambs during the lactation period, it is essential that the nutritional requirements at this stage of life are sufficiently covered. The importance of milk production in the growth of pre-weaned young lamb has been established by a previous study [8]. During the period from birth to weaning, the growth of the young lambs depends on the dairy performance of the mother [9]. Unfortunately, the diet of the latter is generally deficient in nutrients such as proteins and therefore, its milk production does not allow rapid growth of the young lamb whose pre-weaning mortality rate remains high [10]. Increasing the production performance of Arabian ewes through adequate protein supplementation will allow for better lamb weight productivity at farrowing and weaning. This study aims to determine the level of supplementation with fresh leaves of *Acacia albida* to obtain better growth of lambs.

2. Material and Methods

2.1. Study Area

The study was conducted between September 2020 and May 2021 at the small ruminant station of the Livestock Research Institute for Development (IRED) in N'Djamena, Chad. The IRED is in the 1st subdivision of N'Djamena and between 15˚02 East and 12˚08 North at the confluence of the Chari and Logone rivers. The city of N'Djamena is located in the Sahelo-Sahelian zone with a dry tropical climate. The year has two seasons namely the dry season and the rainy season.

The rainy season runs from June to September with an average rainfall varying from 400 to 800 mm according to the north-south gradient. The dry season, which lasts 8 to 9 months, is marked by a hot, dry harmattan wind that sweeps the territory along the North-East to South-West axis. Temperatures range between 20˚C and 40˚C.

2.2. Animal Material and Health Protection

A total of forty-eight (48) Arabian sheep (45 non-pregnant females and 3 males for a sex ratio of 1 ram to 15 ewes) were purchased from local markets and used for these trials. These animals were housed (3 × 2.5 m) in a building on stilts built of planks. The animals were taken out to pasture every morning from 9 am. and returned to their paddock at 5 pm. Their age was determined by the teething analyzing method (20 months on average) [11]. Animals were identified with a collar worn around the neck. They were adapted for 30 days to IRED where they were treated with long-acting Oxytetracyclin (1 ml/10kg of body weight per animal and intramuscularly) and 10% levamisole (1 ml/10kg of bodyweight alive per animal once a month) active on adult gastrointestinal and pulmonary parasites.

2.3. Plant Material

The plant material consisted of the most abundant forage in the pasture (*Dactyloctenium aegyptium*, *Cenchrus ciliaris*, *Panicum maximum*) and *Acacia albida* leaves. These forages were mowed each morning to feed the animals in the sled. Briefly, 300 g of *Dactyloctenium aegyptium* + 300 g of *Cenchrus ciliaris* + 600 g of *Panicum maximum* were harvested and then chopped and the whole mixture constituted the dominant forage of natural pasture.

Three rations were made up or formulated. These rations were randomly assigned to each group for the different studies. The rations were as follows:

- R1- 300 g of *Dactyloctenium aegyptium* + 300 g of *Cenchrus ciliaris* + 600 g of *Panicum maximum* + 0 g of *Acacia albida* leaves: control (group 1);
- R2- 300 g of *Dactyloctenium aegyptium* + 300 g of *Cenchrus ciliaris* + 600 g of *Panicum maximum* + 400 g of *Acacia albida* leaves: (group 2);
- R3- 300 g of *Dactyloctenium aegyptium* + 300 g of *Cenchrus ciliaris* + 600 g of *Panicum maximum* + 600 g of *Acacia albida* leaves: (group 3);

In the evening, when the animals returned from the range, the rations thus constituted were served to the animals according to the groups.

2.4. Trial Conduct and Data Collection

2.4.1. Study of Reproductive Performance

1) Heat synchronization

Heat synchronization was performed using vaginal sponges impregnated with 40 mg fluorogestone acetate (FGA). The sponges were placed for 14 days, followed by an intramuscular injection of 400 international units of pregnant mare serum gonadotropin (PMSG). After the removal of the sponge and injection of PMSG, the first heat appeared after 24 hours. This phase is determined by the ewes' restlessness in search of the ram. Natural mounting of the ewes by the rams was performed 55 hours after the removal of the sponge.

2) Reproduction trial

The ewes were divided into a completely randomized setup, and housed in 3 groups of 15 animals. Three experimental rations with different amounts of *Acacia albida* leaves respectively 0 g, 400 g and 600 g were used to study and evaluate the different parameters of reproduction and growth.

The animals were weighed before gestation. The postpartum weight evolution of the ewes from farrowing to weaning, the number of females that aborted, the birth weight of the lambs, the height, the number of lambs at birth, the viability rate before weaning, as well as the number of weaned lambs and their weight at weaning were recorded.

The data collected allowed us to calculate the following parameters:

- Fertility rate = $\frac{\text{number of ewes that gave birth}}{\text{ewes having given birth}} \times 100$
- Fecundity rate = $\frac{\text{number of stillborn lambs} + \text{number of ewes born alive}}{\text{ewes having given birth}} \times 100$
- Net fecundity rate = $\frac{\text{number of lambs born alive}}{\text{ewes having given birth}} \times 100$
- Litter size = $\frac{\text{number of lambs born}}{\text{ewes having given birth}}$
- Viability at birth = $\frac{\text{number of lambs born alive}}{\text{number of lambs born}} \times 100$
- Viability at weaning or weaning rate = $\frac{\text{number of lambs weaned}}{\text{number of lambs born alive}} \times 100$
- Post-weaning viability = $\frac{\text{number of live lambs at14weeks}}{\text{number of weaned lambs}} \times 100$

2.4.2. Weight Gain

One week after birth, each newborn was identified, weighed and then every two weeks until weaning. Their weights were recorded every two weeks until slaughter (3 months). All weighing was done using an electric scale with a capacity of 60 kg and a sensitivity of 10 g. Total gains (TG) were calculated as the difference between the average weight at the end of each trial period and the average weight at the beginning of the trial period. The average daily gain (ADG) was calculated by the ratio of the GT to the duration of the trial considered. The following growth characteristics were studied:

- Feed intake of lactating females;
- Feed consumption of pre-weaned lambs;
- Weight evolution of lambs from farrowing to weaning;
- Total gain = average start weight − average end weight of the trial

$$\text{ADQ}\left(\frac{\text{g}}{\text{d}}\right) = \frac{\text{Weight of the animal at the end of the period considered} - \text{Weight at the beginning}}{\text{duration of the period under consideration}}$$

2.5. Data Analysis

Data on reproduction, pre-weaning weight growth of newborns, were subjected to one-factor analysis of variance (feed intake) in a completely randomized design.

When there were significant differences between treatments, Duncan's test was applied to separate the means at the 5% significance level [12]. The statistical software SPSS 20.0 (Statistical Package for Social Sciences) was used for these analyses, following the linear model.

3. Results

3.1. Effects of *Acacia albida* Leaf Supplementation on Weight Gain of Lactating Ewes

Figure 1 illustrates the monthly evolution of the live weight of lactating females from farrowing to weaning. The graph shows that during this period, the average weekly weight of lactating females decreased until the sixth week, regardless of the group. In addition, during the first week of lactation, females from the control group had a higher weight than those from the supplemented groups. In contrast, from the second week of lactation to weaning, the weights of females receiving 600 g of *Acacia albida* were higher than those of females from the control and 400 g *Acacia albida* groups respectively. The weight of females receiving 400 g of *Acacia albida* remained low compared to the other groups throughout the trial.

3.2. Effects of *Acacia albida* Leaf Supplementation on the Reproductive Characteristics of Ewes

The effects of *Acacia albida* leaf supplementation on the reproductive performance of ewes showed that litter size, viability at birth and viability at weaning were comparable ($p > 0.05$) regardless of the ration (Table 1). However, there was a significant improvement ($p < 0.05$) in fertility rates, fecundity and net fecundity rates, birth and pre-weaning mortality rates. Indeed, fecundity and net fecundity rates of animals in the supplemented groups were comparable ($p > 0.05$) to each

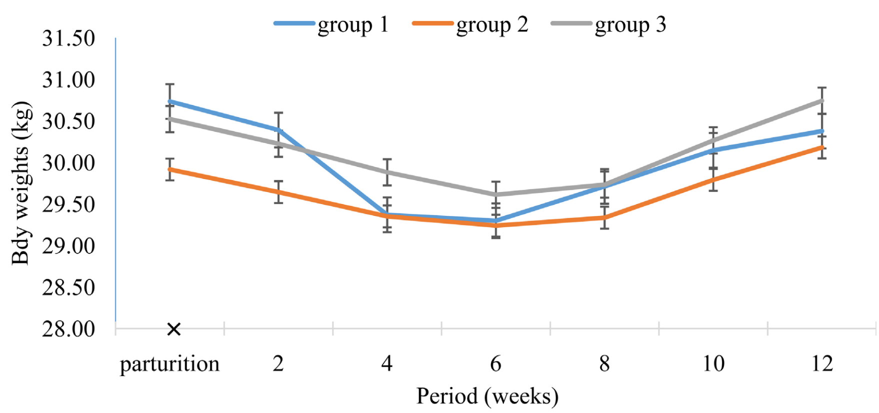

Figure 1. Effects of *Acacia albida* leaf supplementation on weight development of lactating ewes. group 1 = dominant forage in the pasture without Acacia albida; group 2 = dominant forage in the pasture + 400 g Acacia albida; group 3 = dominant forage in the pasture + 600 g Acacia albida.

Table 1. Average reproductive characteristics of ewes according to different levels of inclusion of *Acacia albida* in the rations.

Parameters	group 1	group 2	group 3	p
Fertility rate (%)	80.00[c]	93.03[a]	86.66[b]	0.01
Fecundity rate (%)	80.00[b]	106.66[a]	93.33[a]	0.01
Net fecundity rate (%)	80.00[b]	100.00[a]	93.33[a]	0.02
litter size	1.00	1.14	1.07	0.14
Birth viability rate (%)	100.00	93.75	100.00	0.27
Weaning viability rate (%)	83.33	93.33	85.71	0.40
Birth mortality rate (%)	0.00[b]	6.25[a]	0.00[b]	0.01
Pre-weaning mortality rate (%)	16.66[a]	6.66[c]	14.28[b]	0.01

a, b and c: Values with the same letter on the same row do not differ significantly ($p > 0.05$). group 1 = dominant forage in the pasture without Acacia albida; group 2 = dominant forage in the pasture + 400 g Acacia albida; group 3 = dominant forage in the pasture + 600 g Acacia albida.

other and significantly higher ($p < 0.05$) than those of the unsupplemented groups. Ewes receiving 400 g of *Acacia albida* leaves as a supplement had a significantly higher fertility rate ($p < 0.05$) and lower mortality rate compared to animals receiving 600 g of supplement and those in the control group respectively. In contrast, animals in the control group had significantly higher pre-weaning mortality ($p < 0.05$) than those receiving 400 g and 600 g of supplement respectively.

3.3. Effects of *Acacia albida* Leaf Supplementation on Pre-Weaning Growth Performance of Lambs

❖ **Weight evolution of lambs from birth to weaning**

Figure 2 shows the weight evolution of lambs from birth to weaning. From birth to week 6, lambs from the supplemented groups weighed more than those from the control groups. From the sixth week to weaning (at 12 weeks), the weight of the lambs from the females of the groups supplemented with 600 g of *Acacia albida* leaves was higher than that of the lambs from the females of the control group and the group supplemented with 400 g of *Acacia albida* leaves respectively. At birth, the lambs presented similar weights (2593.45 g). In general, the weight of the lambs increased from birth to weaning. At weaning, the highest weight was obtained with the group supplemented with 600 g of *Acacia albida* leaves (12209.66 g), followed by the control group (11591.05 g) and finally, the group supplemented with 400 g of *Acacia albida* leaves (10404.32 g).

❖ **Weight evolution of male lambs from birth to weaning**

Figure 3 shows the weight evolution of male lambs from birth to weaning. From birth to week 10, the weight of male lambs from the supplemented groups

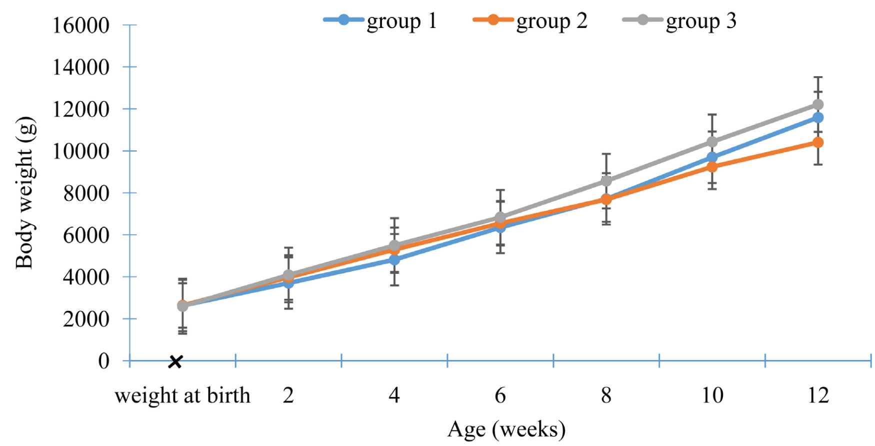

Figure 2. Weight evolution of lambs from birth to weaning. group 1 = dominant forage in the pasture without Acacia albida; group 2 = dominant forage in the pasture + 400 g Acacia albida; group 3 = dominant forage in the pasture + 600 g Acacia albida.

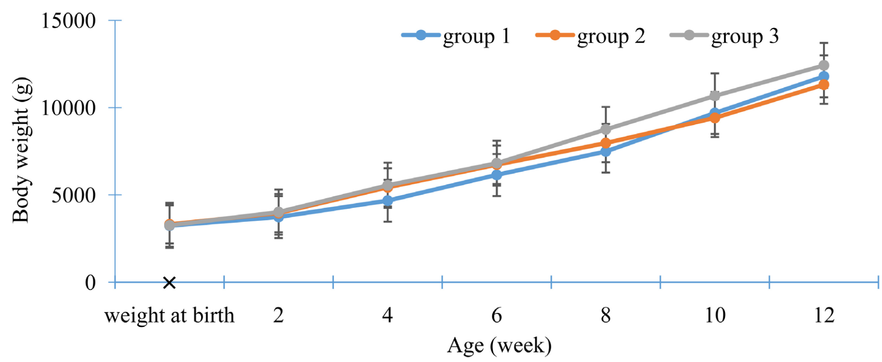

Figure 3. Weight evolution of male lambs from birth to weaning. group 1 = dominant forage in the pasture without Acacia albida; group 2 = dominant forage in the pasture + 400 g Acacia albida; group 3 = dominant forage in the pasture + 600 g Acacia albida.

was higher than that of lambs from the control group. From the tenth week to weaning (at 12 weeks), the weight of male lambs from the females of the groups supplemented with 600 g of *Acacia albida* leaves was higher than that of male lambs from the females of the control group and the group supplemented with 400 g of *Acacia albida* leaves respectively. At birth, the male lambs presented similar weights (3258.44 g).

In general, the weight of male lambs increased from birth to weaning. At weaning, the highest weight was obtained with the group supplemented with 600 g of *Acacia albida* leaves (12419.66 g), followed by the control group (11786.87 g) and at the end, the group supplemented with 400 g of *Acacia albida* leaves (11314.03 g).

❖ **Weight evolution of female lambs from birth to weaning**

The weight evolution of female lambs from birth to weaning is illustrated in Figure 4. In general, it appears from this figure that the weight of female lambs increased from birth to weaning. At weaning, the highest weight was obtained with the group supplemented with 600 g of *Acacia albida* leaves (11579.36 g),

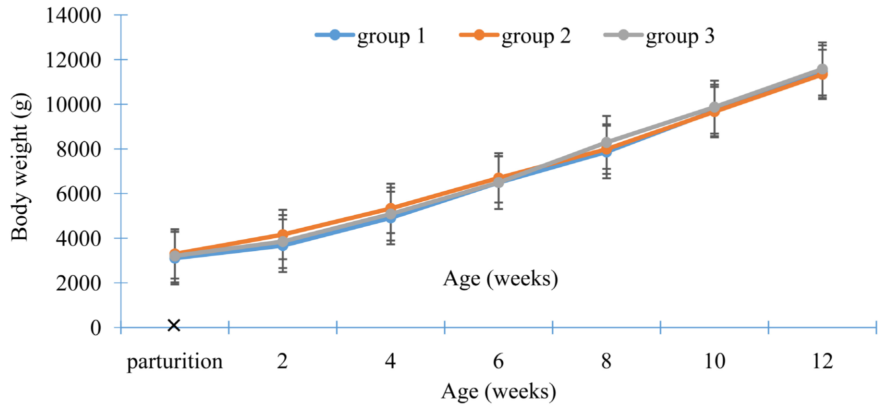

Figure 4. Weight evolution of female lambs from birth to weaning. group 1 = dominant forage in the pasture without Acacia albida; group 2 = dominant forage in the pasture + 400 g Acacia albida; group 3 = dominant forage in the pasture + 600 g Acacia albida.

followed by the control group and the group supplemented with 400 g of *Acacia albida* leaves which had similar weights (11335.78 g).

❖ **Total and average daily gain from birth to weaning of lambs**

The birth weight, weaning weight, total weight gain and average daily gain according to the different levels of *Acacia albida* leaf supplementation in the groups are presented in **Table 2**. From this table it can be seen that the average birth weights of the animals were comparable ($p > 0.05$) for all groups and regardless of sex. The average weaning weight of male lambs in the group supplemented with 600 g of *Acacia albida* leaves was significantly higher ($p < 0.05$) than in the control group and the group supplemented with 400 g of *Acacia albida* leaves, which were otherwise comparable ($p > 0.05$). The same trend was observed for total weight gain and average daily gain of male lambs. Total weight gain and average daily gain of female lambs were comparable regardless of group and sex. Sex had no significant effect on total weight gain and average daily gain.

4. Discussion

The average weight of lactating females decreased from farrowing to weaning in all groups. The decrease in weight observed during this period in ewes could be explained by the fact that during lactation, the mothers spend a lot of energy on milk production to cover the needs of the young, and their own needs are not met [13]. To ensure satisfactory milk production, they are forced to mobilize their body reserves, which would explain the observed weight loss. The results thus obtained are similar to those of Noumbissi *et al.* [14] [15] and Zougou *et al.* [16], who observed a decrease in the weight of suckling guinea pigs from farrowing to weaning when the latter were supplemented with legumes.

Supplementation with *Acacia albida* leaves on the reproductive performance of ewes showed that litter size, birth viability and weaning viability were comparable regardless of group. However, there was an influence on fertility rates, fecundity and net fecundity rates, birth and pre-weaning mortality rates.

Table 2. Birth and weaning weights and weight gains of lambs according to the level of *Acacia albida* leaf supplementation in the ration and sex.

Parameters	Sex	groups			
		group 1	group 2	group 3	p
Average birth weight (kg)	♂	3.23 ± 0.62[a]	3.31 ± 0.05[a]	3.25 ± 0.31[a]	0.942
	♀	3.08 ± 0.58[a]	3.27 ± 0.13[a]	3.24 ± 0.09[a]	0.602
	♂♀	3.15 ± 0.60[a]	3.29 ± 0.09[a]	3.24 ± 0.35[a]	0.772
P		0.861	0.061	0.065	
Average weaning weight (kg)	♂	11.78 ± 0.31[b]	11.31 ± 0.36[b]	12.41 ± 0.52[a]	0.001
	♀	11.46 ± 0.26[a]	11.42 ± 0.17 [a]	11.32 ± 0.26[a]	0.611
	♂♀	11.62 ± 0.28[a]	11.36 ± 0.26 [a]	11.86 ± 0.39[a]	0.306
p		0.589	0.165	0.215	
Total weight gain (kg)	♂	8.54 ± 0.46[b]	8.00 ± 0.37[b]	9.16 ± 0.50[a]	0.001
	♀	7.75 ± 0.16[a]	8.13 ± 0.18[a]	8.08 ± 0.27[a]	0.736
	♂♀	8.14 ± 0.31[a]	8.06 ± 0.27[a]	8.62 ± 0.38[a]	0.368
p		0.128	0.182	0.149	
ADG (g)	♂	101.78 ± 5.48[b]	95.25 ± 4.47[b]	109.06 ± 6.04[a]	0.001
	♀	92.33 ± 19.28[a]	96.89 ± 2.23[a]	96.28 ± 3.28[a]	0.736
	♂♀	97.05 ± 12.38[a]	96.07 ± 3.37[a]	102.67 ± 4.66[a]	0.368
P		0.128	0.182	0.149	

a and b: The means bearing the same letters on the same line are not different at the threshold of $p < 0.05$; A and B: The means with the same letters on the same column are not different at the threshold of $p < 0.05$; p: Probability, ADG: Average daily gain. group 1 = dominant forage in the pasture without Acacia albida; group 2 = dominant forage in the pasture + 400 g Acacia albida; group 3 = dominant forage in the pasture + 600 g Acacia albida.

The average litter size obtained during the present experiment was 1.00; 1.14 and 1.07 respectively for the unsupplemented and the groups supplemented with 400 g and 600 g of *Acacia albida* leaves. The prolificity thus obtained is lower than that of Missoko *et al.* [17] in their work on the reproductive parameters of Djallonke sheep in village environments. Indeed, these authors obtained average litter sizes at first, second and third lambing of 1.38 ± 0.69, 1.4286 ± 0.65 and 2.00 ± 1.41 respectively. The difference observed could be explained by the number of lambings on the one hand and by the breed on the other hand. Indeed, the higher the farrowing rank, the higher the number of lambs per litter.

Fertility, which is the ability to procreate, is evaluated at the flock level by the fertility rate (number of females having lambed on number of females put in reproduction × 100) [18]. In the present study, ewes receiving 400 g of supplementation showed significantly higher fertility. The results thus obtained corroborate those of Blache *et al.* [19], who showed in their work that fertility could be increased by 50% if 400 g of concentrate per day is provided to underfed ewes; on the other hand, a 3-day fasting in this period will decrease fertility by 10%.

Fecundity is the ratio between the number of lambs born alive and dead per mother that has lambed. It is very important to know because the growth rate of the flock and its profitability depends on it (Akouango *et al.*) [20]. Supplementation improved fecundity by 26.66% and 13.33% respectively for the groups supplemented with 400 g and 600 g of *Acacia albida* leaves. The fecundity rate obtained in this study (106.66%) is lower than that of Missoko *et al.* [17] in their work on the reproductive parameters of Djallonke sheep in village settings (147.06%). This rate is also lower than the rates reported by Berger and Ginisty [21] and Boly *et al.* [22], which are respectively 114% to 130% and 108% in extensive farming. Equally, it is lower than the rate of 154% reported by Berger and Ginisty [21] in improved farming. The difference between the rates could probably be explained by the feed. In the experiment of Missoko *et al.* [17], no supplements were given to the animals and they were fed exclusively on natural pastures.

The birth mortality rate obtained during the present experiment was 0%; 6.25% and 0% respectively for the unsupplemented and the groups supplemented with 400 g and 600 g of *Acacia albida* leaves. The birth mortality rate obtained with the group supplemented with 400 g of *Acacia albida* leaves could be explained by the twin litter. Indeed, according to Missoko *et al.* [17], mortality in multiple litters was probably caused by competition for udders within the litter. It could also be due to the inability of the mother to produce enough milk during periods of dearth or in young mothers whose age did not allow them to produce enough milk as they were still growing. Armbruster *et al.* [23] reported mortality rates between 20% and 48% in Djallonke lambs before weaning. Fall *et al.* [24] reported a significant influence of litter size on pre-weaning mortality of Djallonke lambs raised at the Centre de Recherche Zootechnique (CRZ) in Kolda. Gbangboche *et al.* [25]; Missoko *et al.* [26] reported that mortality is higher in triplets or twins than in single born lambs.

The curves of weight growth of lambs have a fairly regular evolution in the different group. Similar work was obtained by Missoko *et al.* [26] on the growth parameters of Djallonké sheep in village settings. Indeed, the latter showed that the weight of the animals increased from the 30th to the 180th month of the trial regardless of the mode of birth. The average birth weights of the animals were comparable for all rations. The lack of significant difference in birth weights was due to the chemical composition of the rations. The average weaning weight of lambs fed the control diet was significantly higher than those fed the diet supplemented with *Acacia albida* leaves. The low average weight of lambs in the treated group observed in this study is similar to that obtained by Benbati *et al.*

[27], who showed that the evolution of live weight was in favor of lambs fed the 0% corn silage diet at 75 days (37.6 kg). In contrast, the results obtained in the present study are contrary to the observations of Dimon *et al.* [28], who showed that animals in the control groups gained approximately 3.53 kg in 75 days compared to 4.83 kg for those supplemented with the *Moringa oleifera*-based rations over the same period. The average daily weight gains (ADWG) obtained by the animals ranged from 86.34 ± 3.62 to 106.81 ± 3.06 g. These results are higher than those of Malam *et al.* [29], who obtained ADWGs of 20.83 to 26.11 g on the zootechnical performance of young male sheep fed moringa (*Moringa oleifera* Lam.) residue supplementation in Niger. They are also higher than those reported by Moncho *et al.* [30], who obtained GMQs of 18.33 g/d to 58 g/d depending on the treatments in a study of multi-nutrient block (MNB) supplementation of Djalonke sheep in Benin. However, they are lower than those reported by Gomma *et al.* [31], who found values ranging from 59 to 118 g/d on the evaluation of feed formulas of multi-nutritional blocks of sheep fattening. Regarding total gains, the results obtained during this study are from 7.77 ± 0.32 kg to 9.61 ± 0.27 kg. These results are much higher than those of Dimon *et al.* [28], with values ranging from 3.53 kg to 4.83 kg for an experiment that lasted 60 days. The differences observed could be explained by the duration of the trial (90 days versus 60 days) and the breed used. Indeed, Dimon *et al.* [28] used Djalonke sheep in their trial.

5. Conclusion

The effects of *Acacia albida* leaf supplementation on reproductive parameters and pre-weaning growth of Arabian lambs showed that the fecundity and net fecundity rate of animals in the supplemented groups were significantly higher than those in the unsupplemented group. Ewes fed 400 g of *Acacia albida* leaves had significantly higher fertility and birth mortality rates. The animals in the control group had a significantly higher pre-weaning mortality rate than those receiving *Acacia albida* leaves as a supplement. The weight of the lambs was increased from birth to weaning. The highest weight was obtained with the ration supplemented with 600 g of *Acacia albida* leaves. The total weight gain as well as the average daily weight gain of male lambs receiving 600 g of *Acacia albida* leaves was significantly higher than those of male lambs from the control and 400 g of *Acacia albida* leaves. Gender had no significant effect on the pre-weaning growth characteristics of the lambs.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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