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Growth of hair lambs in the semiarid highlands of Zacatecas during winter season

Crecimiento de corderos de pelo en el altiplano semiárido de Zacatecas durante el invierno

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ABSTRACT

The aim of the study was to assess the effect of sex, birth type, breed, growth retardation, condition and month of birth on weight of birth (WB), and pre- and post-weaning growth of hair lambs that born during winter (n = 416). Male lambs showed better overall growth performance (P <0.05) than female lambs. Single born lambs weighed more (P <0.05) than multiple born lambs at birth and at weaning, although multiple born lambs had greater (P <0.05) average daily gain (ADG) post-weaning. Blackbelly lambs showed little weight (P <0.05) and growth. Dorper-sired lambs had greater (P <0.05) sale weight (SW) and ADG after weaning than Katahdin-sired lambs. Lambs with growth retardation had lower weight (P <0.05) and general performance. Although lambs born in December had greater (P <0.05) PN, lambs born in February had greater (P <0.05) pre-weaning ADG and SW. In conclusion, the evaluated factors significantly affect both PN and overall growth performance of lambs born in winter in the semi-arid plateau of Mexico.

Keywords: lamb, hair sheep, growth, growth retardation, Mexico.

RESUMEN

El objetivo del estudio fue determinar el efecto del sexo, tipo de parto, raza, condición de crecimiento retardado y mes de nacimiento sobre peso al nacimiento (PN), crecimiento pre- y post-destete de crías ovinas de pelo nacidas en invierno (n=416). Los corderos mostraron mejor (P<0.05) desempeño que las corderas. Las crías de parto sencillo pesaron más (P<0.05) que las de parto múltiple al nacimiento y al destete, aunque las crías de parto múltiple obtuvieron mayor (P<0.05) ganancia diaria de peso (GDP) post-destete. Las crías de madre Blackbelly mostraron menor (P<0.05) peso y crecimiento. La progenie de sementales raza Dorper obtuvo un mayor (P<0.05) peso de venta (PV) y GDP post-destete que la progenie de sementales Katahdin. En las crías valoradas clínicamente con crecimiento retardado se observó un menor (P<0.05) PN y crecimiento en general. Aunque las crías nacidas en diciembre tuvieron mayor (P<0.05) PN, las crías nacidas en febrero presentaron mayor (P < 0.05) GDP pre-destete y PV. En conclusión, los factores evaluados afectan significativamente tanto el PN, y el crecimiento general de las crías nacidas en época invernal en el altiplano semiárido de México.

Palabras clave: corderos, ovinos de pelo, crecimiento, retraso del crecimiento, México.

INTRODUCTION

Sheep have the ability to convert coarse forages into animal protein and produce more efficiently than older ruminants (San *et al.,* 1998). Traditionally, the semi-arid region of Mexico located in the northern mesa of the highlands is recognized for the production of sheep, mainly with the Rambouillet breed in extensive systems, and recently with hair breeds such as the Blackbelly, Pelibuey, Katahdin, Dorper and their crosses. , in semi-intensive production systems (Partida *et al*., 2013). The cost of production in the semi-intensive system is higher than in the extensive system, due to the necessary investments in facilities, equipment, labor and food so these systems must have a high level of productivity to be economically profitable. Therefore, the adequate selection of breeds (paternal and maternal) and the appropriate management of productive indicators from birth to the sale of the lambs should be emphasized (Partida *et al*., 2013).

The hair sheep breeds show great variability in terms of genotypes and productive characteristics (Wildeus, 1997). Indeed, the genotype and other characteristics affect the reproductive and productive performance of the species. In this sense, the advantages of hair sheep are their low reproductive seasonality, greater prolificacy (Galina *et al.*, 1996), resistance to parasites (Vanimisetti *et al*., 2004) and the reduction of costs derived from production and wool shearing (Notter, 2000). However, hair breeds are smaller, have a lower growth rate, and muscle mass, compared to wool sheep breeds. They were developed to be exploited under conditions of warm tropical climates (Wildeus, 1997; Notter, 2000), where winter temperatures are less cold than those prevailing in the Mexican Highlands region, in whose winters polar air mass and night temperatures below 0 °C are recorded (Vidal, 2005).

However, there are no studies in this region that identify the main factors that influence the weight at birth and the development of lambs of hair breeds in winter. Therefore, the objective of the present study was to evaluate some factors such as the effect of sex, type of delivery, the race of the parents, the condition of growth retardation and the month of birth on the birth weight (PN). Besides the pre-weaning and post-weaning growth in hair lambs born in winter in a semi-intensive system in the northern region of the Mexican Highlands.

MATERIAL AND METHODS

Place of study

The present study was conducted during the months of December 2017 to February 2018 at the San Isidro ranch, located in the municipality of Calera de Víctor Rosales, Zacatecas, Mexico. The region belongs to the Mexican highlands and is geographically located at 22° 58'47 "north latitude and 102° 40'49" west longitude. The climate is semi-arid cold BSk, with an annual mean temperature of 17 °C, mean maximum temperature of 30 °C in May, and mean minimum temperature of 3 °C in January, although temperatures are below 0 °C during winter reached (García, 1988).

Animals and measurements

In the present study, 416 offspring born during the winter season were used (single birth n = 242 offspring, 58.2%; double birth n = 135 offspring, 32.4%; triple birth n = 39 offspring, 9.4%). The date of birth, sex (male, female), father's race (Dorper or Katahdin), mother's race (Blackbelly, Dorper, Katahdin and Pelibuey) and type of delivery (single, double or triple) were recorded). In addition, a clinical assessment was carried out from which the offspring were classified as healthy and with growth retardation condition according to the description made by Shelton (1964). It consisted of identifying the offspring with delayed growth characterized due to the presence of shaggy fur, low body development, less vitality and physical strength; while the lambs considered clinically healthy were those that showed a soft coat, good general condition, adequate body development and general vigor. The pups were weighed at birth, at weaning (WW) and at the time of sale (SW) using a digital scale for their completion in other farms. WW were adjusted at 75 d and SW at 145 d of age. The adjusted weights were calculated as WW at 75 d = [(weaning weight-birth weight)/age at weaning in days] × 75 + birth weight, and SW at 145 d = [(final weight - observed weight at weaning)/days elapsed from weaning to final weighing in days] × 70 + weaning weight adjusted to 75 d (Thompson, 2006).

Food and accommodation

The females were fed in daytime grazing (meadow composed of annual rye grass (*Lolium multiflorum* Lam.), *Perennial* rye grass (*Lolium perenne*), bromine grass (*Bromus* willdenowii cv. Matua), fescue (*Festuca arundinacea*), orchard potomac (*Dactylis glomerata*). All this with night confinement and supplementation based on corn stubble, corn silage, alfalfa hay and oats and receiving 300 to 350 g/d of commercial feed (13% CP and 3.4 Mcal ME/kg DM) in the last third of gestation and beginning of lactation. Females were housed in roofed pens at birth where they were kept with their young during the first week of life. The young were at birth weighed and they were within the first 24 h of life identified. Subsequently, the calves went out to graze with their mothers for four to six hours a day, with an initiation supplement "creep feeding" (20% CP and 2.9 Mcal ME/kg DM) in the afternoon. Weaning was carried out at 75 d (two and a half months old), and from at this stage the offspring were fattened with 65% of commercial feed (16% CP and 3.4 Mcal ME/kg DM) and 35% of a mixture of alfalfa hay and oats or ground corn stubble. It was until they were to market sent with an average weight of 34.9 ± 0.4 kg. The animals had free access to fresh water and a mixture of mineral salts in the pen.

Statistical analysis

The statistical analysis of the data was performed with the GLM procedure of the SAS statistical package (SAS Institute, Cary N.C., U.S.A.) version 9.1. The initial statistical model included the main effects and interactions, although since the interactions between simple effects were not significant. In the reduced model only the fixed effects of calf sex (male, female), type of calving (simple, multiple), maternal race (Blackbelly, Dorper, Katahdin, Pelibuey), paternal race (Dorper, Katahdin), clinical assessment (with or without growth retardation) and month of birth (December, January, February). Differences between means were established using Tukey's test (P <0.05).

RESULTS

The sex of the offspring affected (P <0.05) all the evaluated characteristics. Males were heavier (P <0.05) than females at birth (4.0 *vs*. 3.6 kg), at weaning (19.0 vs. 16.0 kg) and at 145 d of age (36.0 vs. 29.0 kg). Furthermore, they showed a higher (P <0.05) pre-weaning ADG (194 *vs*. 169 g), post-weaning ADG (246 *vs*. 181 g) and average ADG (219 *vs*. 175 g). Males gained 4.5 kg more weight (P <0.05) than females between 75 and 145 d of age (Table 1).

The type of delivery affected (P <0.05) the growth of the offspring. Single calving pups obtained higher (P <0.05) WB (4.0 *vs*. 3.5 kg), at weaning (18 *vs*. 16 kg) and at 145 d of age (32 *vs*. 31 kg), in addition to a higher (P <0.05) pre-weaning ADG (188 *vs*. 165 g) and average ADG (195 g *vs*. 188 g) than calves from multiple births. However, the multiple calving pups compensated for the lower previous growth and obtained a higher (P <0.05) post-weaning ADG (213 g *vs*. 202 g), thus achieving a higher (P <0.05) weight gain among the 75 at 145 d of age (15 *vs*. 14 kg) compared to single calving pups (Table 1).

The breed of the mother affected (P <0.05) the characteristics of body weight and pre and post-weaning ADG (Table 2). Regarding WB, the breeds from Pelibuey mothers (4.0 kg) and Dorper (3.9 kg) were heavier (P <0.05) compared to the young from Katahdin females (3.7 kg), while the lambs from Blackbelly mother obtained the lower (P> 0.05) weight (3.0 kg). The WW adjusted to 75 d was higher (P <0.05) for lambs from sheep of the Dorper and Katahdin breeds (18 kg and 17 kg, respectively), followed by lambs from mother Pelibuey (16 kg) and Blackbelly (15 kg). On the other hand, the SW adjusted to 145 d was similar (P> 0.05) among the lambs of the Dorper, Katahdin and Pelibuey breed mothers (32, 32 and 31 kg), and lower (P <0.05) in the breed lambs Maternal Blackbelly (28 kg).

The pre-weaning ADG (0 to 75 d of age) was higher (P <0.05) in the lambs of Dorper mothers (187 g) and similar between the Katahdin (171 g), Pelibuey (167 g) and Blackbelly (164 g). However, the post-weaning ADG (75 to 145 d of age) was higher (P

<0.05) in the offspring of mother Katahdin (219 g), Pelibuey (214 g) and Dorper (198 g) in relation to the offspring from Blackbelly mothers (173 g). In addition, the average ADG (0 to 145 d of age) was higher (P <0.05) in the lambs of Dorper (198 gr), Katahdin (194 g) and Pelibuey (185 g), in relation to the offspring of mothers Blackbelly (173 g).

Table 1. Effect of calf sex and type of parturition on birth weight, at weaning adjusted to 75 d, adjusted to 145 d, the pre-weaning and post-weaning weight gain (mean ± SD) in lambs of hair born in winter in a semi-intensive system of the Mexican Highlands.

	Lamb sex		Type of delivery	
Characteristics	Male (n = 160)	Female (n = 256)	Simple (n = 242)	Multiple (n = 174)
Body weight, kg				
At birth	4.0±0.09^{a}	3.6±0.06^{b}	4.0±0.06^{a}	3.5±0.08^{b}
At weaning adjusted to 75 d	19±0.4^{a}	16±0.2^{b}	18±0.4^{a}	16±0.2^{b}
Adjusted to 145 d	36±0.6^{a}	29±0.4^{b}	32±0.5^{a}	31±0.5^{a}
Daily weight gain, g/d				
Pre-Weaning (0 a 75 d)	194±6^{a}	169±3^{b}	188±5^{a}	165±3^{b}
Post-weaning (75 a 145 d)	246±5^{a}	181±3^{b}	202±4^{b}	213±5^{a}
Average (0 a 145 d)	219±4^{a}	175±3^{b}	195±3^{a}	188±3^{b}

$^{a,\ b}$ Different literals between columns indicate significant differences (P <0.05).

Table 2. Effect of maternal and paternal breed on weight at birth, at weaning adjusted to 75 d, adjusted to 145 d, the pre-weaning and post-weaning weight gain (mean ± SD) in hair sheep pups born in winter in a semi-intensive system of the Mexican Highlands.

	Maternal race				Paternal race	
Characteristics	Blackbelly (n = 36)	Dorper (n = 240)	Katahdin (n = 104)	Pelibuey (n = 36)	Dorper (n = 172)	Katahdin (n = 244)
Body weight, kg						
At birth	3.0 ± 0.13^{c}	3.9 ± 0.07^{a}	3.7 ± 0.09^{b}	4.0 ± 0.11^{a}	3.8 ± 0.08^{a}	3.8 ± 0.07^{a}
At weaning adjusted to 75 d	15 ± 0.5^{b}	18 ± 0.4^{a}	17 ± 0.3^{a}	16 ± 0.3^{b}	17 ± 0.3^{a}	17 ± 0.3^{a}
Adjusted to 145 d	28 ± 1.1^{b}	32 ± 0.5^{a}	32 ± 0.6^{a}	31 ± 0.8^{a}	32 ± 0.5^{a}	31 ± 0.5^{b}
Daily weight gain, g/d						
Pre-Weaning (0 a 75 d)	164 ± 6^{b}	187 ± 5^{a}	171 ± 5^{b}	167 ± 5^{b}	180 ± 4^{a}	177 ± 4^{a}
Post-weaning (75 a 145 d)	182 ±11^{b}	213 ± 4^{a}	219 ± 6^{a}	214 ± 10^{a}	212 ± 5^{a}	202 ± 4^{b}
Average (0 a 145 d)	173 ± 8^{c}	198 ± 3^{a}	194 ± 4^{a}	189 ± 6^{b}	196 ± 3^{a}	189 ± 3^{b}

$^{a,\ b,\ c}$ Different literals between columns indicate significant differences (P <0.05).

The breed of the father did not affect (P> 0.05) the WB, the WW, or the pre-weaning ADG (0-75 d of age). Dorper sire lambs were heavier (P <0.05) at 145 of age (32 kg *vs*. 31 kg) and obtained higher (P <0.05) post-weaning ADG (212 *vs*. 202 g) and average ADG (196 *vs*. 190 g) than lambs of the Katahdin sire breed (Table 2).

Clinically healthy calves obtained a higher (P <0.05) PN than lambs with growth retardation (3.9 *vs*. 3.4 kg), this difference was also observed at weaning (18 *vs*. 13 kg) and at 145 d of age (34 *vs*. 21 kg). In the post-weaning period (between 75 and 145 d), the healthy lambs gained on average 7 kg more (P <0.05) than the stunted lambs (Table 3).

On the other hand, it was observed that lambs born in December (4.6 kg) were heavier (P <0.05) than those born in January (3.8 kg), followed by those born in February (3.6 kg). At weaning and at 145 d of age, lambs born in December and January obtained similar weights (P <0.05), although those born in February (P <0.05) were 4 kg heavier. Furthermore, lambs born in February had higher (P <0.05) pre-weaning ADG and average ADG. No differences were found (P> 0.05) in the post-weaning ADG, nor (P> 0.05) in the adjusted weight at 75 and 145 d of age (Table 3).

Table 3. Effect of clinical condition and month of birth on birth weight, at weaning adjusted to 75 d, adjusted to 145 d, the pre-weaning and post-weaning weight gain (mean ± SD) in hair lambs born in winter in a semi-intensive system of the Mexican Highlands

	Clinical assessment		Birth month		
Característica	Clinically healthy (n = 332)	Growth retardation (n = 84)	December (n = 20)	January (n = 316)	February (n = 80)
Body weight (kg)					
At birth	3.9±0.05[a]	3.4±0.13[b]	4.6±0.25[a]	3.8±0.06[b]	3.6±0.13[c]
At weaning adjusted to 75 d	18±0.3[a]	13±0.2[b]	16±0.3[b]	16±0.2[b]	20±0.8[a]
Adjusted to 145 d	34±0.3[a]	21±0.5[b]	30±0.7[b]	31±0.4[b]	35±0.9[a]
Daily weight gain (g / d)					
Pre-weaning (0 to 75 d)	192±3[a]	124±3[b]	156±4[b]	169±3[b]	223±11[a]
Post-weaning (75 to 145 d)	227±3[a]	123±5[b]	192±8[a]	206±4[a]	212±7[a]
Average (0 to 145 d)	209±2[a]	124±4[b]	173±5[b]	187±3[b]	218±6[a]

[a, b] Different literals between columns indicate significant differences (P <0.05).

DISCUSSION

In correspondence with the results of the present work, several authors (Carrillo and Segura, 1993; Garduño *et al*., 2002; Vicente-Pérez *et al*., 2015) have previously reported the greater weight and development that lambs generally present on the lambs. In this regard, Bores-Quintero *et al*. (2002) observed that during the post-weaning stage the ADGf males exceeded (P <0.05) by 27% the ADG of females. While De Vargas Junior *et al*. (2014), Schanbacher *et al*. (1980), Ghafouri-Kesbi and Notter (2016) conclude that the differences in the weight and development of lambs and ewes that reflect the difference in the endocrine environment and nutrient requirements between the sexes.

The calves born in single birth presented a higher pre-weaning growth rate compared to those born in multiple births, which coincides with that previously reported by Garduño *et al*. (2002), Mellado, *et al*. (2016) and Simeonov *et al.,* (2014). However, the multiple calving lambs compensated for the lower pre-weaning growth and obtained a higher post-weaning ADG to end up with a weight adjusted to 145 d similar to that of the lambs born in single calving. Similar results have been reported by Galaviz-Rodríguez *et al*. (2014) and Simeonov *et al* 2014, and it is considered that during the pre-weaning period, growth is largely determined by the amount of mother's milk. However, once multiple calving lambs are weaned, they consume more feed and they grow at a rate that allows them to reach a weight similar to single-calving lambs at slaughter weight age.

The results obtained in the present study in relation to the maternal breed demonstrate the importance of choosing the bellies that will constitute the maternal base in sheep farms. The weight and development of the lambs will depend on this, mainly taking into account the climatic conditions that occur in this region where the annual thermal oscillation presents differences between the average temperatures at different times of the year from 12 ºC to more than 20 ºC (FAO, 2020). In this regard, Grepe (2001) mentions that the first step in sheep production begins with the choice of breed and the main objective of exploitation.

In this sense, the Dorper breed has shown adaptation and better growth speed (210 to 330 g/d) under grazing conditions in the South African desert (Cloete *et al*., 2000). For its part, the Katahdin breed, developed in the northeast of the United States of America, has been characterized by good productive development (236 g/d) in arid and tropical conditions (Burke and Apple, 2007). Additionally, López-Carlos *et al*. (2010) carried out a study in the Mexican highlands comparing post-weaning growth in sheep of hair breeds. They reported that the Dorper breed offspring (238 g/d) obtained a higher ADG than the Katahdin breeds (226 g/d), Pelibuey (218 g/d) and Blackbelly (188 g / d), with Blackbelly being the one with the lowest productive performance. In this regard, Wildeus *et al*. (2005) mention that the Blackbelly breed offspring have a lower ADG than the Katahdin and Santa Cruz breed lambs (73 g/d *vs*. 109 and 86 g/d, respectively) fed with forage-based diets.

The Dorper and Katahdin paternal breed lambs presented similar WB and WW, in agreement with that reported by Macías-Cruz *et al*. (2010) who observed that the crosses of Dorper and Katahdin studs with Pelibuey females produce offspring for supply with acceptable growth rates, as well as good adaptation in arid climates. However, the progeny of Dorper stud obtained a higher post-weaning ADG and a higher SW (P <0.05) compared to the Katahdin sire lambs, which coincides with that reported by Macías-Cruz *et al*. (2010). He reported that the crossbred lambs of the paternal Dorper breed obtained 16 and 25% more weight per day than those of the paternal Katahdin or Pelibuey breed respectively. In this sense, it is assumed that larger breeds have a higher growth speed than breeds of smaller size or weight at maturity (Owens *et al*., 1993). Although the breeds known as hair have not been evaluated as widely as the wool-producing breeds, it has been reported that the Dorper breed has excellent growth characteristics, for which its use as a terminal breed is recommended, being competitive even when compared with sheep-type meat breeds (Notter *et al*., 2000; Snowder and Duckett, 2003).

On the other hand, in the present study a frequency of 25% of offspring that presented the condition of growth retardation was observed. The foregoing represents the first scientific report that this condition occurs in sheep in Mexico due to the low winter temperatures. However, this condition is of great importance in pigs and has been reported as an important cause of mortality and low productivity in piglets (Wu *et al*., 2006). The stunted growth condition has been reviewed by Wang *et al*. (2017), who indicate that it can manifest itself in all species, being caused by a combination of factors that start from the prenatal period, and is known as "intrauterine growth retardation". This problem is caused by genetic, epigenetic, maternal maturity, and environmental factors such as the mother's nutritional status, stress, illnesses, toxins, etc. According to these authors, intrauterine growth restriction has permanent negative effects on neonatal adaptation, survival and pre-weaning growth, feed utilization efficiency, general lifelong health, body composition, as well as reproductive performance in adult life, and therefore has important implications for animal production.

In relation to the differences obtained in the weight of lambs in winter, it has been shown that pregnant ewes exposed to low ambient temperatures undergo metabolic adaptations to meet the increased energy expenditure associated with the cold. It leads to mobilize body fat and releasing glucose through the liver, which crosses the placenta and increases glucose supply to the fetus, stimulating insulin secretion and fetal growth without apparent risk of clinical ketosis (Kenyon *et al*., 2006; Norouzian, 2015; Symonds *et al*., 1986; Thompson *et al*., 1982). Recently, Piquer *et al*. (2017), explain that the exposure of pregnant rats to 4 °C for 3 h per day caused an increase in the levels of norepinephrine and corticosterone in the maternal circulation, and a decrease in the placental capacity to eliminate norepinephrine from the fetus towards the circulation of the mother. It caused an increase in the weight of the placenta and the body weight of the offspring. The environmental temperatures under which the present study was carried out were colder in December (mean of 10.5 °C and minimum of -9 °C) than in January (mean of 11.6 ° C and minimum of -2 ° C) and February (mean of 13.9 ° C and minimum of -2 ° C). It probably explains why higher birth weights were obtained in lambs born in December.

Adverse environmental conditions due to the combined effect of low temperature, precipitation and wind in the lambing season are the main cause of mortality in hair lambs due to starvation-exposure syndrome (Refshauge *et al*., 2016). In addition, Mellor and Stafford (2004), mention that hair sheep show greater susceptibility to cooling than wool sheep, making them more susceptible to respiratory diseases under cold and humid conditions. In this sense, Saravia and Cruz (2003) mention that, by lowering the air temperature below the minimum critical temperature (10 °C), the point where the production of metabolic heat is insufficient to maintain body temperature and achieve weight gains in lambs. The foregoing would explain why the lambs born in the month of December, despite having obtained a higher WB, subsequently observed a lower weight gain than the lambs born in January and February.

It is important to consider the maternal race, the paternal race and the month of birth in the planning and management of semi-intensive farms with hair sheep, particularly in the climatic and production conditions of the northern part of the Mexican Highlands.

CONCLUSION

The lambs born in single and multiple births, despite showing different WB, reach a similar weight after weaning, the mother's breed determines the WB and the growth of the lambs, and it is not recommended to program Blackbelly female births in the winter months. The breed of the stallion (Dorper or Katahdin) does not affect the birth weight or the initial growth of the lamb, although it determines the post-weaning growth, so the use of the Dorper breed is recommended to improve the weight of sale at 145 d old. Lambs with growth retardation have a lower productive performance than lambs that do not present this delay. Therefore, it is advisable to minimize the incidence of lambs with growth retardation. Lambs born in December have a higher birth weight, although later they obtain lower weight gains than the obtained ones by lambs born in January or February.

IMPLICATION

It is important to consider the maternal race, the paternal race and the month of birth in the planning and management of semi-intensive farms with hair sheep, particularly in the climatic and production conditions of the northern part of the Mexican Highlands. In addition, provide better nutritional conditions to the females during gestation, parturition and lactation, to promote better development of lambs and avoid the condition of growth retardation, since these factors significantly affect the weight at birth and the development of the lambs before and after weaning.

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