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Pre-Weaning Performance of Lambs from Purebred and Crossbred Hair Ewes under Humid Tropical Conditions of Tabasco, Mexico

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Abstract: The objectives of this study were to evaluate the effects of Genetic Maternal Group [GMG: Blackbelly (BB), Pelibuey x Blackbelly (PB) and a Synthetic group (SYN) developed from the mating of Dorper and Katahdin rams on PB ewes] as well as known environmental factors on Birth Weight (BW; n = 5938), pre-weaning Average Daily live weight Gain (ADG; n = 2235) and Weaning Weight (WW; n = 2235) in a commercial flock of hair sheep in Tabasco, Mexico. Final statistical models for analysis of BW, ADG and WW included the fixed effects of Genetic Maternal Group (GMG) of lamb (BB, PB and SYN), Birth Year (BY: 2001-2006 for BW and 2001-2004 for ADG and WW), Birth Season (BS: dry, rains and winds), Birth Type (BT: single, twin), Lamb Sex (LS: male, female) and dam Lambing Number (LN: 1-11). In addition, the ADG and WW models included the linear and quadratic effects of lamb age (LA) at weaning. A GMG x BY interaction was included in these models, since it was a significant effect ($p<0.05$) in a preliminary analysis as well as dam of lamb nested within GMG as a random effect. MGG affected ($p<0.05$) ADG and WW; higher averages were found in lambs from PB and SYN dams. The MGG x BY interaction affected ($p<0.05$) ADG and WW. LA affected ($p<0.01$) ADG in its linear and quadratic effects. All of the environmental factors had a significant effect ($p<0.05$) on the three variables analyzed. In conclusion, PB and SYN dams in this flock produced lambs with higher averages for ADG and WW than lambs from BB dams. According to the performance of the genetic maternal groups there was evidence of a possible genetic x environment interaction. Effects of the various environmental factors should be considered if genetic improvement programs are initiated in this flock.

Key words: Pre-weaning performance, hair sheep, humid tropics, humid, ewes, Mexico

INTRODUCTION

The increased importance of hair sheep under several production systems has been described by Wildeus (1997) in the United States and Nuncio-Ochoa *et al*. (2001) in Mexico. The use of crosses between breeds of hair sheep with the aim of increasing meat production is of great importance in the state of Tabasco, Mexico (Nuncio-Ochoa *et al*., 2001) although, such experiences by producers have not been evaluated having also a partial ignorance of the productive potential of this species in different ecological zones of the country. It was mentioned that breeding animals of high genetic value is a priority research line in Tabasco. Studies carried out in Tabasco under commercial conditions on productive performance (Hinojosa-Cuellar *et al*., 2009) indicate that in the pre-weaning performance the genetic hybrid group of lamb is less important in relation to other factors such as the age at weaning, birth season and birth weight. The aim of this study was to evaluate the pre-weaning performance of lambs from Blackbelly, Pelibuey x Blackbelly and a synthetic group of dams as well as known environmental factors in a commercial flock of the humid tropical region of Tabasco, Mexico.

MATERIALS AND METHODS

Location and animals: Data used in this study were collected from the production records of a commercial flock of hair sheep whose objective is to produce lambs for slaughtering located on the Villahermosa-Frontera highway 60 km, entrance to Miramar 2.5 km, Municipality of Centla, Tabasco, Mexico. This Municipality is located

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at Latitude 18°32' N and Longitude 92°38' W at an altitude of 10 m above sea level. Predominant climate is hot humid with summer rains (with an average of 1696 mm $year^{-1}$). The maximum monthly mean is 357 mm and occurs in September-October. The minimum monthly mean is 100 mm and occurs in April.

The maximum monthly mean temperature is 30.8°C in May and the minimum temperature is 21°C in December and January (INEGI, 2008).

Sheep were fed based on grazing mainly on native grasses in the region such as Remolino (*Paspalum notatum*), Pajon de Sabana (*Paspalum plicatulum*) and Camalote (*Paspalum fasciculatum*). The management of the paddock was rotational; the periods of occupation were variable and were in relation of the dimensions of the pastureland, stocking rate and pasture availability at the time. The rest periods were on average 35 days or so. However, when sheep are stocked to feed her lambs received as a group a commercial concentrate.

At birth the date was recorded and the lamb was weighed within 24 h, registering also the sex of the lambs and the birth type (Single, twin and triplet). Management during lactation was to allow lambs to suckle *ad libitum* during the 1st week. During this period, both ewes and lambs were kept together all the time. From the 2nd week postpartum dams joined the group of sheep grazing out in the morning and returning in the afternoon to the overnight accommodation pen with their lambs. At this stage and until weaning, lambs were fed a commercial concentrate *ad libitum*. Weaning of lambs was carried out at an average of 90.5±14.7 days with a range between 45 and 120 days and they were weighed using a digital platform scale up to 200 kg (100 g precision) at this time date and weight at weaning were registered.

Preventive medicine program in adult sheep included the application of triple bacterin every 6 months to protect them against blackleg, malignant edema and pneumonic pasteurellosis (2.5 mL/animal). The same bacterin was applied to lambs at 90 and 105 days of age (this latter as reinforcement). Then, the schedule of immunization described for adult animals was followed. The control of gastrointestinal parasites was performed every 2 months with levamisole hydrochloride (8 mg kg^{-1} intramuscularly, Ripercol L® 12%).

Data base: Genetic maternal breed groups analyzed were Blackbelly (BB), F_1 Pelibuey x Blackbelly (PB) and a Synthetic group (SYN), the latter formed by the mating of Dorper and Katahdin rams on PB ewes in various proportions. This way, the resulting genotype of lambs was a mixture of the mentioned breeds which is found very frequently in the state of Tabasco. Data constitute 5938 birth dates and Birth Weights (BW) and 2235 dates and Weaning Weights (WW), occurring from 2001-2006 for BW and WW until 2004. The difference between these figures is due to sales, deaths of lambs as no information was available for weaning in 2006. Data with ±3 standard deviations from the mean or triplet births due to the low number of observations (<3%) were not included. For the purpose of statistical analysis if a ewe gave birth to two lambs but weaned only one was considered as a single birth. Only information from the years in which the three genetic maternal groups were contemporary was included, according to the dependent variables under study. Birth dates were grouped into three climatic periods of birth: dry: (February to April), rains: (May to October) and winds: (November to January). The date and weaning weight, lamb sex (male and female), birth type (single, twin) and dam lambing number (1-11) were taken. The dependent variables considered were BW, WW and pre-weaning Average Daily weight Gain (ADG). ADG was calculated resting from WW the BW and dividing the result between the Lamb Ages (LA) at weaning. The LA was calculated in days with dates of birth and weaning.

Statistical analysis: The Mixed Procedure of the Statistical Analysis Software (SAS, 2002) was used for the analysis of the dependent variables. The final statistical model that described the BW included the fixed effects of Genetic Maternal Group (GMG: BB, PB, SYN), Birth Year (BY: 2001-2006), Birth Season (BS: dry, rains, winds), Birth Type (BT: single, twin), Lamb Sex (LS: male, female), Lambing Number (LN: 1-11), GMG x BY interaction and random error ~ N,I (0, σ^2_e). Dam of lamb nested within GMG was included as a random effect. For the analysis of ADG and WW the same model was used but only data up to 2004 were considered. LA was included in its linear and quadratic effect as a continue independent variable.

RESULTS AND DISCUSSION

Descriptive statistics: Overall least-squares means for BW, ADG and WW were 2.9±0.6 kg, 108±33 g and 12.7±2.9 kg, respectively. In Pelibuey lambs weaned also at 90 days under conditions of Cuba, similar values of 2.8 kg, 108 g and 12.6 kg were found (Cero-Rizo *et al*., 1993) for the same variables. In Pelibuey lambs weaned at 90 days in Mexico, values of 2.7 kg in BW, 111 g in ADG and 12.8 kg in WW were obtained by Perez-Ramirez *et al*. (2003). In F_1 Pelibuey x Suffolk and Suffolk x Pelibuey lambs the weaning weight was 15.1 kg, weaned at 90 days (Ramirez *et al*., 1995). Also in Mexico, Quintero *et al*. (2002) found 139 g of pre-weaning daily weight gain in lambs from Suffolk, Dorset and Hampshire rams mated to F_1 Pelibuey x Blackbelly ewes, weaned at 70 days.

Table 1: Least-squares means (±standard error) and number of observations of Birth Weight (BW), pre-weaning average lamb weight gain (ADG) and Weaning Weight (WW) in a flock of hair sheep in the humid tropics of Tabasco, Mexico, according to genetic maternal group, birth year, birth season, birth type and lamb sex

Effect	n	BW (kg)	n	ADG (g)	WW (kg)
Genetic maternal group	-	NS	-	*	*
BB	347	2.8±0.06^{a}	208	95±3^{a}	11.6±0.30^{a}
PB	1805	2.9±0.01^{a}	939	108±1^{b}	12.7±0.16^{b}
SYN	3786	2.8±0.02^{a}	1088	110±2^{b}	12.8±0.24^{b}
Birth year	-	*	-	**	**
2001	666	2.9±0.03^{c}	452	117±2^{a}	13.4±0.22^{a}
2002	772	3.0±0.02^{d}	488	110±2^{b}	12.9±0.18^{b}
2003	1170	3.0±0.02^{e}	767	106±1^{c}	12.5±0.15^{c}
2004	1214	2.8±0.03^{b}	528	85±2^{d}	10.6±0.25^{d}
2005	1428	2.7±0.04^{b}	-	-	-
2006	688	2.6±0.06^{a}	-	-	-
Birth season	-	*	-	*	*
Dry	1387	2.8±0.02^{a}	500	103±1^{a}	12.2±0.14^{a}
Rains	2080	2.8±0.02^{a}	990	111±1^{b}	13.0±0.11^{b}
Wind	2471	2.9±0.02^{b}	745	98±1^{c}	11.8±0.12^{c}
Birth type	-	**	-	**	**
Single	3989	3.1±0.01^{a}	1589	112±1^{a}	13.2±0.10^{a}
Twin	1949	2.5±0.02^{b}	646	95±1^{b}	11.3±0.13^{b}
Lamb sex	-	*	-	*	*
Female	2956	2.8±0.02^{a}	1089	101±1^{a}	12.0±0.11^{a}
Male	2982	2.9±0.02^{b}	1146	107±1^{b}	12.6±0.11^{b}

*Means with the same letters on the right side of each column within each effect are not different ($p<0.05$)

Knowledge of the means of production indices of genetic material evaluated is important because it identifies the production levels expected under specific conditions of management in production systems whose differences in those values can be attributed to variation in climatic conditions and management specific to each location and flock.

Genetic maternal group: Lambs from PB and SYN dams had higher ADG (PB: 108 g, SYN: 110 g) and WW (PB: 12.7 kg, SYN: 12.8 kg) values ($p<0.05$) than lambs from BB dams (ADG: 95 g, WW: 11.6 kg, Table 1). On the one hand, these differences can be attributable to a higher level of milk production of the PB and SYN ewes compared to BB ewes and on the other hand to a possible maternal heterosis effect, not measured here. Information on milk production and their components of hair sheep is very scarce (Godfrey *et al*., 1997) and it is necessary to conduct studies to determine the quantity and quality of milk in these genotypes. Canton studying the productivity of terminal lambs from hair ewes crossed with Suffolk rams, mentioned that milk production of hair sheep breeds is not sufficient to meet the needs of Suffolk-sired lambs.

There was a MGG x BY interaction that affected BW ($p<0.05$) and ADG and WW ($p<0.01$). It can be noted (Table 2) that the means of BW were very homogeneous for all maternal groups in all years except 2006 in which the highest BW was obtained by the SYN group. Moreover in 2004 for ADG and in 2003 and 2004 for WW differences in those variables in the three maternal groups were significant ($p<0.01$) indicating that these genotypes respond to environmental conditions in a different way, thus evidencing a possible genotype x environmental interaction (Falconer and Mackay, 1996).

Table 2: Least-squares means (±standard error) of Birth Weight (BW), pre-weaning average daily weight gain (ADG) and Weaning Weight (WW) in a flock of hair sheep in the humid tropics of Tabasco, Mexico, according to genetic maternal group x birth year interaction

Genetic maternal group x Birth year	n	BW	N	ADG (g)	WW (kg)
BB-2001	117	2.9±0.05^{a}	84	112±3^{a}	13.0±0.33^{a}
PB-2001	455	3.0±0.03^{a}	312	118±2^{a}	13.5±0.24^{a}
SYN-2001	94	2.9±0.06^{a}	56	120±4^{a}	13.7±0.41^{a}
BB-2002	75	3.0±0.06^{a}	56	106±4^{a}	12.6±0.40^{a}
PB-2002	365	3.0±0.03^{a}	233	114±2^{a}	13.2±0.24^{a}
SYN-2002	332	2.9±0.04^{a}	199	110±3^{a}	12.8±0.29^{a}
BB-2003	76	3.0±0.06^{a}	46	98±5^{a}	11.7±0.50^{a}
PB-2003	378	3.1±0.03^{a}	256	111±2^{a}	13.0±0.21^{b}
SYN-2003	716	3.0±0.03^{a}	465	108±2^{a}	12.8±0.23^{a}
BB-2004	44	2.7±0.09^{a}	22	65±9^{a}	9.0±0.84^{a}
PB-2004	304	2.8±0.03^{a}	138	89±2^{b}	10.9±0.25^{b}
SYN-2004	866	2.7±0.02^{a}	368	101±2^{c}	11.9±0.24^{c}
BB-2005	28	2.6±0.10^{a}	-	-	-
PB-2005	218	2.8±0.03^{a}	-	-	-
SYN-2005	1182	2.7±0.02^{a}	-	-	-
BB-2006	27	2.2±0.10^{a}	-	-	-
PB-2006	85	2.6±0.05^{a}	-	-	-
SYN-2006	596	2.7±0.02^{b}	-	-	-

*Means with the same letters on the right side of each column within each year are not different ($p<0.05$)

Birth year: Although, in the years 2001 and 2003, there was an increase in BW from 2004 on BW tended to decrease (Table 1). Means between years of ADG and WW tended to decrease over time, reaching the lowest value in 2004. The year effect on these variables tended to be negative over time, suggesting that environmental conditions where the animals were got worse. Moreover, the total number of lambs increased but not the area in which they grazed. A similar situation was found by Ramirez *et al*. (1995) working with purebred lambs and F_1 lambs of Pelibuey and Suffolk breeds who reported that the effect of birth year was negative on the birth weight which according to these researchers suggest a worsening in the conditions in which they had the animals over time. In this type of studies where researchers work with data from commercial farms where the management of animals is subject to wide variations of environmental and financial type is common to find differences ($p<0.01$) in variables of productive type due to the year of birth. In relation to the above, the results of this study agree with other studies under similar humid environmental conditions (Perez-Ramirez *et al*., 2003; Hinojosa-Cuellar *et al*., 2009).

Birth season: The highest BW (Table 1) was observed in lambs born in the windy season (2.9 kg) while the highest values for ADG and WW (111 g and 13.0 kg, respectively) were obtained in the rainy season. The high ADG and WW values in the rainy season coincide with the increased availability of forage in this region which help to explain these results. Benyi *et al.* (2006) found differences in birth weight of crossbred West African lambs ($p<0.01$) due to the climatic season of the year (better in the rainy season than in dry season) however, this difference was not maintained in the weaning weight (adjusted to 150 days of age). The effect of birth season also has been found by other researchers in various sheep breeds (Tuah and Baah, 1985; Taye *et al.*, 2010) which suggests that the effect of season on pre-weaning lamb performance not only depends on the amount of milk available to the lamb as a result of forage supply but also of other factors such as the ability of the lamb to consume milk and dietary supplements.

Birth type: Lambs born as singles weighted more at birth, at weaning and had higher daily weight gains ($p<0.01$), 3.1 kg, 113 g and 13.3 kg, respectively compared with lambs born as twins, 2.5 kg, 95 g and 11.3 kg in that same order (Table 1), equivalent to a superiority in favor of single lambs of 24.0, 18.9 and 17.6% for those same variables. In this regard, Hinojosa-Cuellar *et al.* (2009) reported similar values of 18.2, 12.3 and 10.9% of superiority in favor of lambs of single origin in BW, ADG and WW. In another study under experimental conditions, working with Pelibuey x Blackbelly sheep found that litter size and birth type influenced ($p<0.05$) ADG of lambs (56 days of lactation) with twins lighter than singles. In this same study, ADG in single lambs from primiparous and multiparous ewes and in twin lambs from multiparous sheep were: 201±17, 199±11 and 163±7 g, respectively. In support of this, Combellas *et al.* (1997) obtained 3.3 and 2.3 kg for single and twin lambs, respectively. Gonzalez *et al.* (2002) indicated for Blackbelly lambs a BW of 3.1 kg in single lambs and 2.5 kg in twins which is equivalent to 19.4% more weight for single lambs which they attributed to single lambs having no competition for food or for space while being in the uterus.

These same researchers noted that at weaning the difference for single lambs was 15.2%, explained by the fact that whole milk production is used only for one lamb. Most researchers agree on the superiority of single lambs in relation to twin lambs (Gonzalez *et al.*, 2002; Hinojosa-Cuellar *et al.*, 2009), triplets (Combellas *et al.*, 1997; Rastogi, 2001) and multiple (Figueireido *et al.*, 1982; Benyi *et al.*, 2006).

Table 3: Least-squares means (±standard error) of Birth Weight (BW), pre-weaning Average Daily weight Gain (ADG) and Weaning Weight (WW) in a flock of hair sheep in the humid tropics humid of Tabasco, Mexico according to lambing number

Lambing number	n	BW (kg)	n	ADG (g)	WW (kg)
1	1207	2.7±0.03^{a}	483	87±2^{a}	10.6±0.22^{a}
2	1058	2.8±0.03^{b}	407	99±2^{b}	11.8±0.21^{b}
3	916	2.9±0.03^{c}	360	102±2^{c}	12.2±0.21^{c}
4	755	2.9±0.03^{c}	279	99±2^{b}	11.9±0.21^{b}
5	573	2.9±0.03^{c}	224	105±2^{c}	12.5±0.22^{c}
6	454	2.9±0.03^{c}	153	109±2^{c}	12.8±0.25^{d}
7	351	2.8±0.03^{b}	116	110±3^{c}	12.9±0.28^{c}
8	240	2.9±0.03^{b}	91	104±3^{c}	12.3±0.31^{bc}
9	164	2.7±0.04^{a}	66	102±4^{c}	12.0±0.38^{bc}
10	101	2.9±0.05^{c}	25	112±6^{c}	13.2±0.59^{bc}
11	119	2.8±0.06^{b}	31	118±8^{c}	13.5±0.76^{bc}

*Means with the same letters on the right side of each column are not different ($p<0.05$)

Lamb sex: Males had a superiority of 10.3, 10.5 and 10.4% in BW, ADG and WW over females (Table 1). Hinojosa-Cuellar *et al.* (2009) obtained 6.5, 5.6 and 7.8% of difference ($p<0.01$) in favor of males in these same variables in lambs weaned at 85 days old and Carrillo *et al.* (1987) obtained 6.4 and 4.7% of difference ($p<0.01$) in BW and WW also in favor of males when they were weaned in the limits from 80-130 days. Tuah and Baah (1985) pointed out that the rate of skeletal growth in the uterus is faster for males than for females and causes a higher birth weight in males and consequently a faster growth up to weaning. This increased growth can be explained because in males the testosterone which is an androgen secreted by the testes is involved in the metabolism of protein (Ashdown and Hancock, 1980) and stimulates protein anabolism by increasing nitrogen retention. The results of this study agree with those obtained by Rajab *et al.* (1992) and Carrillo and Segura (1993).

Lambing number: Lambs born from primiparous ewes had the lowest values ($p<0.01$) in the three variables under study compared with lambs born from ewes from second to eleventh lambing in which the differences were consistently higher compared to the first lambing (Table 3), a fact that is attributed to the age of the ewe (Perez-Ramirez *et al.*, 2003) since, as the lamb matures and reaches its full body development, the ewe becomes more efficient to maintain a pregnancy, produces more milk and expresses her maternal ability. Carrillo *et al.* (1987) mentioned that with increasing age of the sheep there is a progressive increase in weight of the lambs which is confirmed by the results obtained by Zambrano (1997) who noted that for every additional day of age of the ewe at birth WW was increased in 1.3 g ($p<0.05$). Unlike the findings in this study, Acosta-Morales found no difference between primiparous and multiparous ewes with a single lamb, possibly because birth weights were similar ($p>0.05$) between the groups of sheep studied.

Covariate (Weaning age): Results indicated that as LA increased there was a corresponding decrease of 56.9 g in a linear effect and an increase of 504 g in WW in its quadratic effect ($p<0.05$). Similarly, as LA increased there was a corresponding decrease of 3.8 g in ADG in its linear effect and an increase of 16 g in its quadratic effect ($p<0.01$). The decrease in ADG observed in this flock may be explained because at this age the milk production of the ewe is not enough to maintain in an upward trend WW and ADG of lamb which seems to be confirmed because milk production is maximum between the first and 2nd week after which there is a rapid gradual decrease (Castellanos and Valencia, 1982; Combellas *et al*., 1997). In support of this, a gradual reduction in ADG from day 11 of age is documented in Pelibuey lambs (Mora-Morelos *et al*., 2005) suggesting a need for studies on milk production in these genetic groups to confirm the results. On the other hand with advancing LA lambs relay more on solid feed intake (concentrate supplement offered in corral) than on maternal milk which may partially explain the quadratic positive effect on ADG. Carrillo *et al*. (1987) mentioned that LA does not affect the variance of WW in Pelibuey lambs weaned between 80 and 130 days old in agreement with results obtained in the present study. The reduction in ADG by increasing LA agrees with the results obtained by other researchers (Rastogi, 2001; Hassen *et al*., 2002). Hassen *et al*. (2002) reported that for every day of increase in LA, ADG decreased 56 and 47 g in native lambs and in crosses of these with Awassi weaned at 30 and 60 days, respectively. These same researchers (Hassen *et al*., 2002) indicated that in his study the postpartum ewe weight helped them to produce enough milk to nurse their lambs, thus showing a higher ADG.

CONCLUSION

The use of Pelibuey x Blackbelly and synthetic ewes favored higher average daily gains and weaning weights of their lambs, compared to Blackbelly ewes. There was evidence of a possible genetic x environment interaction according to the performance of the genetic maternal groups studied. There are common environmental factors that have an influence on pre-weaning performance of the lambs and should be considered when initiating genetic improvement programs.

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