The Journal of Animal & Plant Sciences, 24(5): 2014, Page: 1303-1308
ISSN: 1018-7081

EFFECT OF THREE PRODUCTION SYSTEMS OF CENTRAL MEXICO ON GROWTH PERFORMANCE OF FIVE LAMB GENOTYPES

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ABSTRACT

A year study was undertaken to evaluate the effects of three contrasting management systems: year-round grazing (G), G plus cereal crop residues and grain supplementation (GS) and year-round pen feeding (PF) on performance of five genotypes of lambs in central Mexico. The variables type of birth (single/twin), sex (male/female), time of birth (dry/wet) and season of birth (autumn, winter, spring, summer) were studied. Genotype (5 breed groups) on birth weight (BW), weaning weight (WW), final weight (182 days of age; PW) and pre and post-weaning daily weight gains (DWG) were also studied. Live weight of the variable response showed a significant effect of breeds ($P<0.0001$), season ($P=0.0031$), type of birth ($P=0.0005$), and interaction in the production system x time x type of birth in the year ($P=0.0038$). There was also interaction in the production system x time x type of birth ($P=0.0425$). The overall weights (means ± standard error) for BW, WW, and PW were 4.8 ± 1.7, 20.6 ± 5.0 and 28.9 ± 7.0 kg, respectively. Means DWG were 187, 100 and 135 kg for pre-weaning, post-weaning and total weight, respectively. In general, wool lambs had better performance than hair lambs Thus, sheep production system in the high plateau of central Mexico have an important effect of lamb performance.

Key words: Lamb production, Environmental factors, Birth weight, Weaning weight.

INTRODUCTION

The sheep industry in Mexico is far from satisfying the internal market of meat (mainly "barbacoa", rich and spicy lamb meat (Rubio *et al.*, 2004), tempered by the taste of smoke from an earthen pot) and prime cuts. About 50% of the national demand for sheep meat has been met with import during the last 15 years and price of sheep meat is higher than meats of other farms animals (Morales *et al.*, 2004). The sheep population remained static for a long time and productive efficiency in terms of reproduction and production remained at low level due to conventional husbandry practices (Segura *et al.*, 1996). Flocks management is mainly empiric, with total disregard of health and genetic improvement programs.

Mexico has a wide range of ecosystems where sheep are raised. Native pastures or crop residues are used as main sources of feed (Morales *et al.* 2004). However, their overutilization causes malnutrition and land degradation, with ecological deterioration which lowers productive efficiency. About 53% of sheep flocks are concentrated in the high Plateau of central Mexico. These flocks are composed of specialized (reduced focus on wool quality and an emphasis on carcass attributes) and majority are non-specialized breeds with no genetic improvement programs. Climatic conditions of the central Mexican plateau are adequate for appropriate lamb feeding systems, thus, local production systems could be improved by adopting good feeding programs in conjunction with the use of proper breeding schemes suitable for this eco-region (SAGARPA, 2012).The purpose of this study was to assess genetic and non-genetic factors affecting birth weight, weaning weight and gain from birth to weaning in lambs from different production systems in central Mexico.

MATERIALS AND METHODS

Study area: The study was carried out in six areas in the central High Plateau of Mexico, geographically at 19°22' and 19°45' north latitude and 97°52' and 98°43' west longitude with an altitudeof 2,650 m. The climate is sub-humid warm, with an annual average temperature of 15°C and 300 to 500 mm annual precipitation (SAGARPA 2012). The area comprises 180,720 ha, where corn, wheat and barley constitute important crops. Sheep production mainly (75%) depends on cereal crops or residues in the state of Tlaxcala.

Classification of the Production Units: The study was carried out using 15 sheep flocks that were grouped into three production systems, according to feeding systems:

a) Grazing (G). Sheep depended solely on native grasses (*Brachypodiummexicanum, Muhlenbergiarigida, Boutelouagracilis*, *Boutelouacurtipendula*, among others) that grow in the rainy season, and the use of post-harvest residual crops (wheat, barley and maize straw) during the dry season. During October to March, lambs are fed only with native vegetation with 8 to 10 hours of grazing per day. From April to September sheep are fed barley straw and corn stover. Sheep flocks had free access to water in the morning and afternoon. Sheep flocks are confined at nights to avoid predator attacks and robberies. Lambs in this production system depended on milk from their dams and later on grasses.

b) Grazing plus supplement of cereals grains (GS): Feeding of lambs was similar to G, but additionally, they were supplemented with 300 to 600 g of barley, corn or wheat grain and 500 g of ground corn stover per animal , mainly in the rainy season (April to September). Animals also received water twice a day. Lambs in these flocks also depended initially on their mother´s milk but at the same time were supplemented with grain. Lambs had little access to grain, due to the competition with their own mothers and the limited space of the feeding troughs.

c) Pen feeding (PF): The flocks are fed in corrals. The basal diet consisted of ground corn stover and/or barley straw (5.9% CP and 1.35 Mcal ME/kg DM) plus a mixture of cereal grains (corn, barley and oat). The grain mix (14% CP and 2.2 Mcal EM/kg DM) is exclusively offered in feeding troughs, sheep remain in permanent confinement and they had free access to water. Lambs have access to the feed by using feeders designed for them. In the three sheep production systems, only 15% of the producers occasionally provided minerals to sheep.

Study variables: Five hundred and ten lambs of five genotypes (Suffolk (S): 131, Hampshire H: 88, wool x hair crosses (Ramboillet x Suffolk x Churraon Pelibuey x Blackbelly: WH): 110, Suffolk x Hampshire (SH): 89 and Pelibuey (PB): 92 animals), classified into 3 production systems (only grazing: 143, grazing + grain: 276, pen feeding: 91 animals) were used. Ear tags were used for identification of each lamb; additionally lambs were painted a number on the right flank. Weight of lambs was registered using a digital scale, immediately or within 48 h after birth. Animals remained with their mothers inside the flock according to the management of the producers and the general handling of the flock according to each production system. Animals were grouped by period and season of the year. The periods were: wet (April to September) and dry (October to March). Lambs were also grouped according to type of birth (single vs. twins) and sex. Lambs were weighed every 14 days. Birth weight (BW), weaning after 84 days (WW), body weight at 182 days of age (PW) and daily weight gains (DWG) pre-and post-weaning were used for statistical analyses.

Analysis and statistical model: The data were analysed using the GLM procedure of SAS (SAS 2007) and significant differences between means were compared with the Tukey test ($p < 0.05$). The statistical model was:

$$Y_{ijklmn} = « + S_i + R_j + EP_k + ES_l + TP_m + SE_n + (S * EP)_{ik} + (S * TP)_{im} + (S * SE)_{in} + (S * EP * SE)_{ikn} + £_{ijklmn}$$

Where:

$« =$ Over all mean

$S_i =$ Effect of i^{th} sheep production system

$R_j =$ Effect of the j^{th} sheep breed within each sheep production system

$EP_k =$ Effect of the k^{th} time of the year: rainy or dry

$ES_l =$ Effect of the l^{th} season of the year, spring, summer, autumn and winter

$TP_m =$ Effect of the m^{th} type of birth, single or twin

$SE_n =$ Effect of the n^{th} sex of lamb, female or male

$(S * EP)_{ik} =$ Effect of the interaction between the i^{th} sheep production system and the k^{th} time or season of the year

$(S * TP)_{im} =$ Effect of the interaction between the i^{th} sheep production system and the m^{th} birth type

$(S * SE)_{in} =$ Effect of the interaction between the i^{th} of sheep production system among the n^{th} sex of the born lamb

$(S * EP * TP)_{ikn} =$ Effect of the interaction among the i^{th} production system, the k^{th} time or season of the year and the m^{th} birth type

$£_{ijklmn} =$ Residual error term

RESULTS AND DISCUSSION

Birth weight of lambs: Lamb birth weight was affected by breed of lamb (P <0.0001, Table 1), season of the year (P=0.0031), birth type (P=0.0005) and the interaction production system x time of the year (P=0.0038). For weaning weight, a significant effect of breed (P<0.0001), type of birth (P=0.0188) and the interaction production system x time x birth type (P=0.0425) was detected. In this last case the interaction production system x birth type was also significant but this is not discussed because it is second order interaction. Finally, live weight at 182 days of age was influenced by breed (P <0.0001) and sex (P=0.0002). The weight gain of the animals during the experimental phase had a significant effect for the pre-weaning gain (P<0.0001), post-weaning (P=0.0028) and final weight (P<0.0001). There were interactions in production of system x season (P=0.0279), time x season (P=0.0049). The other interactions included in the considered statistical models did not show statistical significance (P<0.05). In both cases the rest of the interactions were not significant (P>0.05).

The overall birth weight of, regardless sheep production system and breed was of 4.83 ± 1.67 kg. The birth weight falls within the range of 4.1 to 5.0 kg found for other breeds such as Suffolk, Hampshire, Texel and Oxford (Maxa *et al.*, 2007). Other studies carried out in the same area had registered average birth weights of 5.6 kg for Columbia (DeLucas *et al.* 2003) and 2.7 kg for Blackbelly breeds (González *et al.* 2002). Lambs on PF system presented lighter (P <0.001) birth weight (22.3% less weight) than lambs on G or GS systems (Table 1).

On the other hand, time and season influenced (P<0.001) birth weight; lambs born in the dry season were 19.4% heavier than lambs born in the wet season.This effect may be attributed to a greater a post-crop forage availability. A similar response has been reported by González *et al.* (2002) and DeLucas *et al.* (2003). Lambs born in fall and winter were 19.5% heavier (P<0.001) than those born in in spring and summer. Similar responses were reported in wool lambs (Yilmaz *et al.* 2007). In this study, single lambs were 22% heavier (P <0.001) than twins, and males were 10.9% heavier (P<0.001) than females. Comparable results were reported by DeLucas *et al.* (2003), Cloete *et al.*(2007), Corner *et al.* (2007), Yilmaz *et al.* (2007), Akhtar *et al*., 2012 and Javed *et al*., (2013). In this study, pure breed lambs (Suffolk and Hampshire) were heavier (P<0.01) than other breeds (Table 1). Moreover, birth weight of S was 27% heavier (P<0.001) than H lambs.

Lambs weaning weight (84 days): Neonatal mortality was around 8% and there were not differences among breeds (P>0.05). Most sheep producers do not wean their lambs, thus in this study lamb weight at 84 days was registered, considering that the recommendation is to wean lambs between 70 and 90 days of age (Combellas *et al.* 1980). Average weight of the lambs at 84 d of age was 20.6 ± 4.9 kg.This value approaches values from other studies (15 to 22 kg; Dixit *et al.* 2001; Matika *et al.* 2003; Javed *et al.*, 2013).

Weaning weight of lambs on GS system was 27%, heavier (P<0.001) than those in G or PF systems; whereas weaning weight of lambs on G or PF were similar (Table 1). This response can be explained by the fact that, in PF system, ewes were kept with crosses of breeds that are supposed to express hybrid vigor. In this study, weaning weight of lambs born in the dry season was 24% higher (P<0.001) than lambs born in the wet season. This could be explained by the fact that lambs born in dry season were heavier at birth than those born in wet season.Weaning weight of S lambs were 12.1, 23.4, 27.9, and 42.3% heavier P<0.001) than H, WH, PB and SH, respectively (In general weaning weight of lambs in the present study were greater than Merino lambs at 90 d of age (15.0 kg; Dixit *et al.* 2001) and lower (21 kg) than Texel, Shropshire, Oxford, and Suffolk lambs at 60 d of age (Maxa *et al.* 2007).

Weight of the lambs at 182 days: The mean weight of lambs at 182 days was 28.86 ± 6.98 kg. Lambs on G (28.2 kg) or GS (29.1 kg) systems were not different (P>0.05); however, were higher (P<0.001) that those on PF system (25.5 kg). Weight of lambs at 182 d of age during the dry season (30.0 kg) were heavier (P<0.001) that those on the wet season (25.26 kg). Season of the year also influenced weight of the lambs at 182 days; lambs in the fall weighed 30.1 kg in winter 29.7,in spring 25.4 in summer and 25.84 kg in fall, respectively.

Daily weight gain: Regardless of breed, season and other non-genetic factors, mean pre-weaning DWG in the 510 lambs was 187 g, post-weaning DWG was 100 g and for final weight (at 182 d of age) was 135 g. Pre-weaning DWG, was higher in GS (P<0.001) followed by PF and G production systems (Table 1). Results in G system was comparable to the 0.271 kg/day obtained by DeLucas *et al.* (2003) and by Bimczok *et al.* (2005) who reported that lambs on an artificial feeding systems with milk substitutes daily weight gains of 0.227 kg and 0.209 kg without substitutes. Lambing in this study were during the dry season, with climate and environmental condition favorable for their first weeks of life, as well as the availability of straw which allows the ewes to have a better body condition at the end of gestation and a greater production of colostrums and milk (Dwyer 2008; Hashemi *et al.* 2008).

During the post-weaning period, lambs on G system had the highest DWG (P<0.001) followed by PF and GS systems. It seems that after 56 days of age, the association of milk production and lamb growth is lower and not significant. As lambs grow they depend less on milk increasing their dependence on forage and feed supplements (Dwyer 2008; Hailu *et al.* 2006). During the pre-weaning, post-weaning, and final periods, lambs during the dry season presented higher DWG than lambs in the wet season. Moreover, single lambs had better performance during the pre-weaning stage than lambs born as twins (Table 1). However, during the post-weaning and final periods DWG were lower. Similar responses were reported for Merino lambs both during the pre- and post-weaning periods (Dixit *et al.* 2001). Suffolk lambs, during the pre-weaning period, had the highest DWG (P<0.001) followed by H, WH, PB and SH

Table 1. Performance of lambs of different genotype under different raising systems at the Mexican High Plateau. Values are means ± standard error

Item	Number at birth	Birth weight, kg	Number at weaning	Weaning weight, kg	Preweaning DWG, g	Number Post-weaning	Post-weaning weight, kg	Post-weaning DWG, g	Final DWG, g
Sheep production system									
Only grazing	143	4.9±0.1[a]	113	17.6±0.6[b]	152±6[c]	66	28.2±1.1[ab]	121 ± 7[a]	0.131 ± 0.006[b]
Grazing + grain supplement (S)	276	5.0±0.1[a]	228	22.4±0.4[a]	205±4[a]	82	29.1±0.9[a]	090 ± 5[c]	0.139 ± 0.004[a]
Pen feeding	91	3.8±0.1[b]	73	18.4±0.7[b]	175±7[b]	56	25.5±1.4[b]	097 ± 0.011[b]	0.122 ± 0.008[c]
Time									
Dry (October-March)	365	5.1±0.1[a]	314	21.6±0.4[a]	196±4[a]	126	29.9±0.7[a]	0.107 ± 0.005[a]	0.140 ± 0.003[a]
Wet (April-September)	145	4.1±0.1[a]	100	17.4±0.5[b]	157±6[b]	78	25.2±1.0[b]	0.079 ± 0.006[b]	0.117 ± 0.005[b]
Season of the year									
Fall	144	5.0±0.1[a]	124	20.7±0.6[a]	185±0.006[ab]	59	30.1±0.9[a]	0.123±0.006[a]	0.141±0.004[a]
Winter	224	5.1±0.1[a]	171	22.1±0.4[a]	203±0.005[a]	67	29.7±1.1[ab]	0.093±0.007[ab]	0.139±0.005[a]
Spring	91	4.4±0.1[b]	71	18.2±0.7[b]	167±0.007[b]	48	25.4±1.1[b]	0.070±0.006[b]	0.117±0.005[b]
Summer	51	3.8±0.1[c]	48	15.8±0.8[c]	139±0.009[c]	30	25.8±2.2[b]	0.108±0.016[a]	0.122±0.011[b]
Type of birth									
Single	407	5.0±0.1[a]	339	20.9±0.3[a]	189 ± 0.004[a]	145	29.1±0.7[a]	0.098 ± 0.005[b]	0.134 ± 0.003[b]
Twin	103	4.1±0.1[b]	75	18.8±0.7[b]	175 ± 0.007[b]	59	27.8±1.5[a]	0.111 ± 0.009[a]	0.136 ± 0.007[a]
Sex									
Female	266	4.6±0.1[b]	227	19.9±0.4[b]	181 ± 0.005[b]	124	27.2±0.6[b]	0.086 ± 0.004[b]	0.127 ± 0.003[b]
Male	244	5.1±0.1[a]	187	21.4±0.4[a]	93 ± 0.005[a]	80	32.7±1.3[a]	0.136 ± 0.009[a]	0.154 ± 0.006[a]
Breed									
Suffolk	131	6.1±0.1[a]	106	23.8±0.4[a]	209 ± 0.005[a]	48	34.3±0.9[a]	0.114± 0.007[b]	0.155 ± 0.005[a]
Hampshire	88	4.8±0.2[b]	73	20.9±1.1[b]	192± 0.012[ab]	36	33.6±2.5[a]	0.117 ± 0.014[b]	0.159 ± 0.012[a]
Wool x hair	110	3.5±0.1[c]	96	18.2±0.4[c]	174 ± 0.005[b]	58	23.4±0.9[b]	0.060 ± 0.005[d]	0.111 ± 0.004[c]
Pelibuey	92	3.4±0.2[c]	67	17.2±0.6[c]	165 ± 0.006[b]	32	27.2±1.3[b]	111 ± 0.011[c]	0.132 ± 0.007[b]
Suffolk x Hampshire (SFxHP)	89	3.8±0.2[c]	72	13.7±0.6[d]	118 ± 0.007[c]	30	27.6±1.3[b]	145 ± 0.009[a]	0.132 ± 0.007[b]

BW = birth weight; DWG = daily weight gain. [ab]Means in columns with different superscript letter are significantly different ($P<0.05$).

(0.118). These results are lower than those reported by Rosa *et al.* (2007) in Romney Marsh lambs, and similar to that for Merino lambs. Gonzalez *et al.* (2002) reported lower values in Blackbelly compared to our results with PB. In the present study males gained more weight than females, during the post-weaning and final weight. Similar responses were observed in other studies with several breeds and conditions (Bosso *et al.* 2007; Rosa *et al.* 2007; Yilmaz *et al.* 2007; Javed *et al*., 2013). Other studies confirm that wool breeds show a better performance than hair breeds (Burke and Apple 2007; Lupton *et al.* 2007).

It was concluded that The GS system provides the best alternative system for lamb production at the high plateau in central Mexico but at a significantly lower investment relative to PF system. Year round grazing with cereal crop residues and grain supplementation increased lamb birth and weaning weights and total weight relative to lambs from other production systems. Wool lambs were more suitable for any of the production systems.

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