Short Communication

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Growth and pre-weaning mortality of Katahdin lamb crosses¤

Crecimiento y mortalidad pre-destete de corderos híbridos Katahdin

Crescimento e mortalidade pré-desmame de cordeiros híbridos Katahdin

Miguel Mellado[1], Zoot, PhD; Ulises Macías[2], Zoot, PhD; Leonel Avendaño[2], Zoot, PhD; Jesús Mellado[1], Zoot, PhD; José Eduardo García[1*], Zoot, PhD.

[1]*Universidad Autónoma Agraria Antonio Narro, Departamento de Nutrición Animal, Saltillo 25315, México.*

[2]*Instituto de Ciencias Agrícolas, Universidad Autónoma de Baja California, Valle de Mexicali, México.*

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Summary

Background: Katahdin breed sheep is highly disseminated in Mexico. This breed and its crosses have recently gained attention among sheep producers. However, research with crosses between Katahdin and other meat breeds is limited. **Objective:** to evaluate the genetic and non-genetic factors affecting growth and mortality rate of crossbred lambs from Katahdin ewes fecundated with breeds specialized for meat production. **Methods:** crossbred lambs (n = 152) from Katahdin ewes sired with Hampshire (KH; n = 43), Texel (KT; n = 53) or Charolais (KCH; n = 56) were evaluated under intensive management conditions. The effects of genotype and non-genetic factors on birth weight, weaning weight, pre-weaning daily weight gain, and mortality rate were determined. **Results:** breed differences were not detected for birth weight (4 ± 1.1, 4.3 ± 0.9 and 4 ± 1.1 Kg for KCH, KH, KT, respectively), nor for the 60-d weaning weight (20.2 ± 4.3, 20.9 ± 4.3, 18.2 ± 4.2 Kg for KCH, KH, KT, respectively). Weight of lambs did not differ significantly between sexes, but it decreased ($p<0.05$) with increased litter size (weaning weight at 60 days for single, twins and triplets was 24.5 ± 2.6, 19.2 ± 3.5, and 14.3 ± 3.8 Kg, respectively). Pre-weaning mortality of KH lambs was 13.3% and it was significantly lower than that of the other genotypes (24.5 and 39.3% for KT and KCH, respectively). **Conclusion:** inclusion of Charolais, Hampshire or Texel rams in Katahdin flocks results in similar lamb weaning weight, but Hampshire-sired progeny excels regarding pre-weaning survival.

Keywords: *birthweight, Charolais, Hampshire, Texel, weaning weight*.

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* Corresponding author: José Eduardo García. Departamento de Nutrición Animal, Universidad Autónoma Agraria Antonio Narro, Saltillo, 25315, Mexico. Email: edugarmartz@gmail.com

Resumen

Antecedentes: la raza de ovejas Katahdin se ha difundido ampliamente en México. Esta raza y sus cruces han ganado recientemente la atención de los productores de ovinos; sin embargo, la investigación con cruces entre Katahdin y otras razas productoras de carne es limitada. **Objetivo:** evaluar factores genéticos y no genéticos que afectan las tasas de crecimiento y mortalidad de corderos hijos de ovejas Katahdin fecundadas con razas de carne. **Métodos**: corderos híbridos (n = 152) derivados de ovejas Katahdin fecundadas con machos Hampshire (KH; n = 43), Texel (KT; n = 53) y Charolais (KCH; n = 56) se evaluaron bajo condiciones intensivas de manejo. Se determinó el efecto del genotipo y factores no genéticos en el peso al nacer, peso al destete, ganancia de peso pre-destete, tasa de ganancia de peso pos-destete y mortalidad de los corderos. **Resultados:** no se detectaron diferencias entre grupos raciales para el peso al nacer (4 ± 1,1, 4,3 ± 0,9 y 4 ± 1,1 Kg para KCH, KH, KT, respectivamente) ni para el peso al destete realizado a los 60 días (20,2 ± 4,3, 20,9 ± 4,3, 18,2 ± 4,2 Kg para KCH, KH, KT, respectivamente). Los pesos de los corderos no difirieron significativamente entre sexos, pero disminuyeron ($p<0,05$) con el aumento del tamaño de la camada (el peso al destete a los 60 días para los corderos individuales, gemelos y trillizos fue 24,5 ± 2,6, 19,2 ± 3,5 y 14,3 ± 3,8 Kg, respectivamente). La tasa de mortalidad pre-destete de los corderos KH fue de 13,3% y fue significativamente más baja que la de los otros genotipos (24,5 y 39,3% para KT y KCH, respectivamente). **Conclusión:** el uso de sementales Charolais, Hampshire o Texel en rebaños de ovejas Katahdin genera resultados similares para peso de los corderos a los 60 días, pero la progenie de los moruecos Hampshire tiene mayor sobrevivencia hasta el destete.

Palabras clave: *Charolais, Hampshire, peso al destete, peso al nacimiento, Texel.*

Resumo

Antecedentes: Katahdin é uma raça de ovelhas altamente disseminada no México. Esta raça e seus cruzamentos têm recentemente ganhado atenção entre os produtores de ovinos. No entanto, a pesquisa com cordeiros híbridos entre Katahdin e outras raças de carne é ainda limitada. **Objetivo:** avaliar os fatores genéticos e não-genéticos que afetam a taxa de crescimento e a taxa de mortalidade de cordeiros híbridos de ovelhas Katahdin fecundadas com raças de carne. **Métodos:** cordeiros cruzados (n = 152) derivados de ovelhas Katahdin fecundados com carneiro Hampshire (KH; n = 43), Texel (KT; n = 53) e Charolais (KCH; n = 56) foram usadas neste estudo sob condições intensivas. Foi determinado o efeito do genótipo e dos fatores não-genéticos sobre o peso ao nascimento, peso ao desmame, peso pré-desmame e percentagem de sobrevivência. **Resultados:** não foram detectadas diferenças raciais por peso ao nascimento (4 ± 1,1, 4,3 ± 0,9 e 4 ± 1,1 Kg para KCH, KH, KT, respectivamente), e peso ao desmame aos 60 dias (20,2 ± 4,3, 20,9 ± 4,3, 18,2 ± 4,2 Kg para KCH, KH, KT, respectivamente). Os pesos dos cordeiros não diferiram significativamente entre os sexos, mas o peso diminuiu ($p<0,05$) com o aumento do tamanho da leitegada (o peso ao desmame aos 60 dias de cordeiros individuais, gêmeos e trigêmeos foi de 24,5 ± 2,6, 19,2 ± 3,5 e 14,3 ± 3,8 Kg, respectivamente). A taxa de mortalidade pré-desmame dos cordeiros KH foi de 13.3% e este foi significativamente menor do que a taxa de mortalidade de cordeiros dos demais genótipos (24,5 e 39,3% para KT e KCH, respectivamente). **Conclusão:** o uso de carneiros Hampshire, Charolês ou carneiros Texel em ovelhas Katahdin pode ser implementado com resultados semelhantes para o peso do cordeiro ao desmame, mas a descendência Hampshire destacou-se por sua maior sobrevivência até o desmame.

Palavras chave: *Charolês, Hampshire, peso ao desmame, peso ao nascer, Texel.*

Introduction

As sheep operations intensify in Mexico, it becomes important to enhance the efficiency of meat production. Crossbreeding can be used to improve lamb production efficiency, but the Mexican sheep industry has yet to determine the optimum production system and which specific crosses will result in the highest profitability under intensive management conditions.

The introduction of a number of sheep breeds in Mexico during the last decades has contributed to improve the productivity of indigenous breeds (Bores-Quintero *et al*., 2002; Cuéllar, 2007). Katahdin, one of these introduced breeds, has been widely disseminated in Mexico because of its easy care, lamb production, tolerance to internal parasites (Burke and Miller, 2004), resistance to harsh environments (Marai *et al*., 2007), good fertility and capacity to reproduce in spring (González-Godínez *et al*., 2014; Burke, 2005) and good efficiency of forage utilization (Wildeus *et al*., 2005, 2007; Brown *et al*., 2012). However, Katahdin, as most hair sheep, are generally smaller and have lower growth rates than traditional wool sheep (Wildeus *et al*., 2007).

Thus, crossbreeding between hair-sheep and meat-type sheep with superior growth to increase lamb production seems to be a feasible alternative to increasing sheep productivity, as has been demonstrated by a limited number of studies in Mexico (Partida de la Peña *et al*., 2009; Vázquez-Soria *et al*., 2011). The number of lambs marketed per ewe favorably impacts profitability (Braga Lôbo *et al*., 2011), but liveweight of lambs also constitutes a major factor determining the total Kg of lamb weaned or marketed from a sheep flock. Therefore, improving total weight of lamb weaned is important for Katahdin producers because sale of meat is the primary source of income. This aspect is becoming more important as intensive sheep operations are rapidly increasing in Mexico. Poorly executed crossbreeding programs may bring disappointing results. This research was undertaken to evaluate genetic and non-genetic factors influencing growth traits and mortality rates of crossed lambs from Katahdin females with Charolais, Hampshire, and Texel meat breeds.

Material and methods

Ethical considerations

This experiment was conducted in conformity with the "Guiding principles for research involving animals and human beings" approved by the Council of the American Physiological Society (Published 1 August 2002 Vol. 283 no. 2, R281-R283 DOI: 10.1152/ajpregu.00279.2002). Ethical considerations did not arise during the course of the study.

Animals

The study was conducted in a commercial sheep farm in central Mexico (20 °N, 550 mm rainfall, 1940 m above sea level; 16 °C annual median temperature) between September and November 2013. One hundred and twenty-eight multiparous Katahdin (K) ewes were separated into 3 groups. Estrus of all ewes was synchronized with intravaginal sponges containing 20 mg fluorogestone acetate (Chronogest®, Intervet, Mexico) for 12 days. Ewes in estrus were detected with intact rams wearing an apron to prevent copulation. Ewes in estrus were inseminated in the uterus 12 hours after the beginning of estrus with non-frozen semen (laparoscopy) from Texel (n = 6), Hampshire (n = 6) or Charolais (n = 5) rams. Ninety-two ewes lambed and 152 crossbred lambs were born (53 Texel, 43 Hampshire and 56 Charolais).

Sheep were kept in shaded open-sided pens with dirt floor. Feed bunks were located at the front of each pen. Late pregnant ewes were kept in individual lambing pens with no bedding for better care during lambing. Lambs were kept together with their dams in these pens. All lambs were weighed within 12 h after birth using a platform scale weighing from 0 to 20 Kg and reading to 0.1 Kg. Lambs were again weighed individually at 30 and 60 days of age. Average daily gains (ADG) from birth to 60 days were registered. Lambs were ear tagged at birth and birth date, type of birth and gender were recorded. Lamb mortality was recorded as number of lambs born dead or alive dying within 60 days post-lambing.

All lambs were offered a total-mixed diet *ad libitum*. The diet met the NRC (2007) recommendations for maximum growth rate (2.90 Mcal metabolizable energy (ME)/Kg dry matter (DM) with 20% crude protein (CP) (Lamb Tech, Purina®, Salamanca, Mexico) from approximately 14 d of age and until weaning at 60 days of age. Lamb survival was defined in this paper as the number of lambs weaned per 100 lambs born (dead and alive). The lamb survival trait was coded as follows: 0 = dead if any lamb recorded at birth subsequently had no live weight recorded at 60 days, and 1 = alive, if it survived at 60 days so that a binomial analysis of this trait could be used.

Statistical analysis

Growth data were analyzed with the MIXED procedure of SAS (SAS version 9.4, 2013, SAS Inst., Inc., Cary, NC, USA). The model measured fit effects on lambs of breed, gender, litter size and three two-way interactions between variables. The non-significant interactions were removed from the final model. Means were compared using the probability of a statistical difference (PDIFF option of SAS). The effect of genotype group, gender, litter size (one to three offspring) and birth weight of lambs (three categories: <3.5, 3.5-4.5, and >4.5 Kg) and their interaction with mortality (yes/no) until weaning was assessed with a logistic model (Proc Genmod of SAS). Comparison of means was carried out using the Least Square/DIFF procedure of SAS. Statistical differences were considered significant at $p<0.05$.

Results

No interactions were statistically significant for any trait. Therefore, only main effects are described. Breed of sire was not significant for birth weight (Table 1). Likewise, weaning weights were similar ($p>0.10$) among breed types, but KH and KCH lambs had higher ($p<0.05$) weight gain from birth to weaning than KT lambs (Table 1). Contrary to expectation, lamb gender was not a significant source of variation for birth and weaning weight, as well as pre-weaning daily gain. Lambs coming from higher litter sizes had lower ($p<0.05$) birth weights than single-born lambs across all breed groups (Table 1). Breed by type of birth interaction was not significant; therefore, the reduction in birth weight of triple-born lambs compared to single-born lambs was 2.1 Kg for all breeds.

Overall, 27.6% of the lambs (42/152) died before 60 days of age. Mortality rate was significantly lower for KH lambs compared to KCH and KT lambs (Table 2). There was no significant difference in lamb mortality attributable to litter size and gender ($p>0.05$). Heavy lambs at parturition exhibited lower ($p<0.05$) mortality rates than lighter lambs. On the other hand, light-born lambs experienced the highest rate of mortality ($p<0.05$).

Table 2. Pre-weaning lamb mortality in an intensive system in central Mexico, as a function of genotype, litter size, birth weight, and gender.

Item	Number	Mortality rate (%)
Genotype group		
Katahdin x Charolais	22/56	39.3^{a}
Katahdin x Hampshire	7/43	16.3^{b}
Katahdin x Texel	13/53	24.5^{a}
Litter size		
1	9/31	29.0
2	27/104	26.0
3	6/17	35.3
Birth weight (Kg)		
<3.5	21/39	53.9^{a}
3.5-4.5	16/56	28.6^{b}
>4.5	5/57	8.8^{c}
Gender		
Males	19/75	25.3
Females	23/77	27.6

Within ítems, means with different superscript letters ($^{a,\ b,\ c}$) indicate significant difference ($p<0.05$).

Table 1. Growth performance of progeny sired by Charolais (CH), Hampshire (KH), and Texel (T) breeds on Katahdin ewes in central Mexico.

Item	Birth weight, Kg	30-d weight, Kg	60-d weight, Kg	Average daily weight gain 0-30 d, g	Average daily weight gain 0-60 d, g
Breed					
KCH	4.0 ± 1.1	11.3 ± 2.4	20.2 ± 4.3	243 ± 63	270 ± 64^{a}
KH	4.3 ± 0.9	11.5 ± 2.4	20.9 ± 4.3	241 ± 68	277 ± 59^{a}
KT	4.0 ± 1.1	10.7 ± 2.6	18.2 ± 4.2	224 ± 67	237 ± 61^{b}
Gender					
Female	3.9 ± 1.0	11.0 ± 2.2	19.4 ± 3.9^{a}	236 ± 61	258 ± 71
Male	4.2 ± 1.0	11.3 ± 2.7	20.1 ± 4.8^{b}	237 ± 72	265 ± 72
Litter size					
1	4.8 ± 0.9^{a}	13.9 ± 1.9^{a}	24.5 ± 2.6^{a}	303 ± 53^{a}	328 ± 56^{a}
2	4.1 ± 0.8^{b}	10.8 ± 1.9^{b}	19.2 ± 3.5^{b}	223 ± 56^{b}	252 ± 60^{b}
3	2.7 ± 0.7^{c}	8.2 ± 1.3^{c}	14.3 ± 3.8^{c}	183 ± 45^{c}	193 ± 83^{c}

Values are means ± SD. Means within the same column with different superscripts letters ($^{a,\ b,\ c}$) indicate significant difference ($p<0.05$).

Discussion

Different to other studies with hair sheep (Freking and Leymaster, 2004; Osorio-Avalos *et al*., 2012) sire breed did not alter birth weight of lambs. Values for this trait, regardless of genetic group, were higher than the 3.3-3.9 Kg reported for purebred Katahdin lambs (Burke *et al*., 2003; Hinojosa-Cuellar *et al*., 2009; López-Carlos *et al*., 2010) or hair x meat sheep crossbred lambs (Cardoso *et al*., 2013) from well-fed mothers. On the other hand, birth weight of purebred Texel and Charolais lambs observed in other studies (Christley *et al*., 2003; Yaqoob *et al*., 2004) is higher than weight found in the present study for Texel and Charolais-sired lambs. Thus, it seems that the use of meat-type sires on Katahdin ewes resulted in an intermediate birth weight of these hybrid lambs, as it has been observed in other studies (do Prado Paim *et al*., 2013; Ríos-Utrera *et al*., 2014). In addition, clearly there was not a genetic component accounting for some of the variation in birth weight of these lambs.

Lamb gender did not affect birth or weaning weight, nor pre-weaning daily gain, which is not in accordance with various reports indicating that ram hair lambs grow faster than withers (Cloete *et al*., 2007; Ríos-Utrera *et al*., 2014). But a number of reports indicate no differences in weight and daily gain between male and female hair lambs (Hinojosa-Cuéllar *et al*., 2012; Cardoso *et al*., 2013).

Breed group did not affect weaning weight, which is in agreement with observations by Hinojosa-Cuellar *et al*. (2011) on crossbreed Pelibuey x Blacbelly and Katahdin x hair sheep. Likewise, Malhado *et al*. (2009) found similar weaning weight between Dorper x Morada Nova and Dorper x Rabo Largo sheep. This trait is strongly affected by maternal environment and it seems that the good mother ability of Katahdin ewes caused the similar weaning weight observed among genotypes.

ADG from birth to weaning was higher in KH and KCH lambs. This trait is a common measurement of growth and is an economically important characteristic in the breeding of mutton sheep. In addition, this trait has a high genetic and phenotypic correlation with feed efficiency (Cammack *et al*., 2005). Pre-weaning ADG was higher than the weight gains reported by Vázquez-Soria *et al*. (2011), Macías-Cruz *et al*. (2012) and Moreno-Cáñez *et al*. (2013) for pure or crossbred Katahdin lambs in intensive systems in central and northern Mexico.

Similar to findings in multiple previous studies, lambs from higher litter sizes had reduced birth weights compared to single-born lambs across breed groups. Lamb characteristics at birth were in agreement with Godfrey *et al*. (1997), Osorio-Avalos *et al*. (2012) and Ríos-Utrera *et al*. (2014), who reported that single born lambs are heavier at birth and grow faster than twins and triplets.

Mortality of lambs in the present study is much higher than that observed with other well-fed hair lambs (Macías-Cruz *et al*., 2012; Knights *et al*., 2012) but close to the findings by Cloete *et al*. (2007) with Dorper ewes crossbred to meat sheep. The extent of pre-weaning mortality is a complex issue. It is influenced by the lamb capability for survival, the ewe's maternal ability, and to management practices at lambing and during the rearing period (Nowak and Poindron, 2006; Sawalha *et al*., 2007). The fact that birth weight of lambs was similar among genotypes suggests that factors other than birth weight were involved in the deaths of lambs.

In the present study, a many deaths were due to dystocic parturition. This condition is associated with increased risk of lamb loss (Hinch and Brien, 2014; Holmøy *et al*., 2014). The marked difference in lamb mortality between genotype groups remains unexplained. Heritability for lamb survival is extremely low (Brien *et al*., 2010; Hatcher *et al*. 2010), hence the interactions between rearing ability of the mother, lamb viability, and climatic conditions around lambing possibly accounted for the difference in the incidence of lamb losses among genotype groups.

In the present study, male and female lambs had similar chances of surviving to weaning. This is in agreement with results of Matos *et al*. (1993), who found that males and females have similar survival rates, but it does not agree with previous studies both in wool (Sawalha *et al*., 2007; Hatcher *et al*., 2009; Everett-Hincks *et al*., 2014) and hair sheep (Holmøy *et al*., 2012; Hinch and Brien, 2014), where male lambs had higher mortality than females. Contrary to the above-mentioned studies, Atashi *et al.* (2013) found that Iranian male lambs showed higher survival rate than females. It could be that Katahdin dams are not drastically affected by the greater size and weight at birth of male lambs, which leads to longer labor, compared to females (Dwyer, 2003) and eventually tend to have higher mortality than females.

In this study, either no consistent superiority was observed of singles or twins compared with triplet-born lambs in terms of survival to weaning. This result does not agree with previous reports (Gama *et al*., 1991; Matos *et al*., 1993) where increased litter size lead to decreased lamb survival. On the other hand, other researchers observed that lamb survival was higher for lambs born as twins compared to singles (Everett-Hincks *et al*., 2005). The hybrid nature of all lambs in the present study could have reduced the risk of hypothermia or starvation, which is characteristic of smaller lambs from large litters (Kerslake *et al*., 2010). This study suggests that Katahdin ewes did apparently not display the result and competition between lambs for milk supply was not strong.

Regardless of birth type, higher weaning weights were associated with lower mortality risk, whereas the risk of mortality at weaning was greater for lambs with low weaning weight. These results agree with those by several authors (Sawalha *et al*., 2007; Hatcher *et al*., 2009; Boujenane *et al*., 2013). This study suggests that selection programs for increased birth weight in crossbred animals would reduce lamb mortality.

The present study indicates that under intensive management conditions, farmers with flocks of Katahdin ewes would expect similar weaning weight of lambs from crossbreeding these ewes with either Charolais, Texel or Hampshire sires. However, higher survival to weaning can be expected for Hampshire-sired litters compared to Texel and Charolais-sired lambs.

Conflicts of interest

The authors declare they have no conflicts of interest with regard to the work presented in this report.

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