

# Effect of maternal intrinsic factors on productivity and efficiency at weaning in commercial flock of Pelibuey ewes in the tropic of Tabasco, Mexico

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## ABSTRACT

**Objective:** To evaluate maternal intrinsic effects (body weight, body condition score, udder type, litter size, lamb sex) on litter growth traits (litter weight at lambing [LBW] and at weaning adjusted for 70 days [LWW70]) as a criteria of productivity and some indexes of efficiency in Pelibuey ewes.

**Design/Methodology/Approach:** Data of body weight (BW), body condition scores (BCS), and udder types (UT) were taken at lambing, likewise at weaning BW (WBW), on 48 multiparous Pelibuey ewes. Additionally, litter size, sex, birth and weaning weight, were recorded for each offspring; this information was used to calculate LBW, LWW70, average daily gain (ADG), and the following indexes: Ewe efficiency (EEF) expressed as kg of lamb weaned per kg ewe BW at lambing,  $EEF^{0.75}$  expressed as kg of lamb weaned per kg ewe metabolic BW ( $BW^{0.75}$ ) at lambing, and  $EEF2$  expressed as kg of lamb weaned  $\pm$  ewe BW gained or lost at weaning per kg ewe BW at lambing. For statistical analysis, ewes were classified according to BW (low, medium and high), BCS (low and high) and udder type (I, II, III and IV) at lambing. High BW ewes had greater ( $P \leq 0.01$ ) LLW and LWW70 than low BW ewes.

**Results:** Ewe BW at lambing did not affect ( $P > 0.05$ ) any productivity index. Also, BCS from lambed ewes did not alter ( $P > 0.05$ ) the productivity parameters. The udder type affected only LWW70 and productivity indexes, being similar among ewes with type-I, II and III udders, but lower in ewes with type-IV udders. Likewise, double litters were heavier at birth and weaning than single litters, affecting EEF and  $EEF^{0.75}$ , but not EEF.

**Conclusions:** The Pelibuey ewe's productivity in humid tropic depends on the maternal BW, udder type at lambing and prolificacy, being a better productivity when ewes have a high BW, double lambing and non-misshapen udders.

**Key words:** Hair ewes; pre-weaning growth; udder score; lactating sheep.

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## INTRODUCTION

In the tropical regions of Mexico, hair sheep play an important role due to its contribution in the national meat production, and represents a great alternative for tropical agricultural diversification, as they can be raised both in extensive and intensive systems (Chay-Canul *et al.*, 2016). So, the lamb production is one of the main activities in tropical areas of southeastern Mexico, where Pelibuey is the main hair breed used as maternal line due to their prolificacy, low reproductive seasonality, rusticity and high adaptation capacity to extreme climate (Gutierrez *et al.*, 2005; Chay-Canul *et al.*, 2016; Chay-Canul *et al.*, 2019).

Pelibuey sheep are being raised for meat production, and in consequence, farmers are interested in identifying productive traits for selection purpose to improve the ewe productivity. An interesting trait is related to amount of lamb kilograms per ewe at weaning, but without dramatically increasing production costs. In order to improve ewe efficiency or productivity (composites and complex traits), it is important to recognize some intrinsic maternal factors altering the potential to produce heavier litters per ewe lambled (Iñiguez and Hilali 2009; Lôbo *et al.*, 2011). Breed, individual variation between ewes, body size, body condition score, age, mothering ability, milk production, udder morphology, prolificacy, and lamb growth and survival rate are factor associated with the ewe productivity (Fogarty, 1995; Safari *et al.*, 2005). For example, ewes' body weight (BW) is used as a selection criterion between and within breeds because it has a positive correlation with birth and weaning lamb weight (Fogarty, 1995; Segura *et al.*, 1996; Petrović *et al.*, 2012). In addition, ewe BW at lambing has a positive correlation with milk production and, therefore, lamb pre-weaning growth, but with a greater energy maintenance cost (Ángeles *et al.*, 2013; Hinojosa-Cuéllar *et al.*, 2019). However, more information is required on the impact of maternal BW on Pelibuey ewe productivity.

Ewe efficiency can also be evaluated by measuring weaning litter weight (WLW) or through the ratio of WLW: live or metabolic BW of the ewe at lambing (Lôbo *et al.*, 2012; Chay-Canul *et al.*, 2019). Moreover, recently Beard *et al.* (2019) reported that the poor conformation of udder and teats may reduce the profitability of livestock production systems due to decreased offspring weaning weight, increased incidence of mastitis, and decreased productivity lifetime of females. Additionally, udder conformation may negatively affect milk yield available for offspring pre-weaning development (Ugarte and Gabina, 2004; Beard *et al.*, 2019). It should be mentioned that, for hair breed raised in tropical production systems, there is limited information of the effects of udder conformation at parturition on the production of weaning lamb per ewe. For the aforementioned, it was hypothesized that ewe BW and body condition score (BCS), udder type (UT), litter size, and offspring sex affect pre-weaning growth in Pelibuey breed lambs, which in turn modifies productivity and efficiency of the dams. Therefore, the aim of this study was to evaluate the effects of ewe BW, BCS, udder type, litter size and lamb sex at lambing on LWW, average daily gain (ADG) in lambs as a criterion of ewe productivity and efficiency under humid tropic conditions of southeastern Mexico.

## MATERIALS AND METHODS

### Experimental site, animals, and handling

All animal handling was carried out in compliance with guidelines and regulations for ethical animal experimentation according to División Académica de Ciencias Agropecuarias, Universidad Juárez Autónoma de Tabasco. The experiment was carried out at the Sheep Integration Center of the Southeastern (Centro de Integración Ovina del Sureste [CIOS]; 17° 78" N, 92° 96" W; 10 masl), located on the km 25 + 3 of the Villahermosa-Teapa road, in the state of Tabasco, Mexico.

This study was conducted with 48 multiparous Pelibuey ewes, which had at lambing an average BW of  $29.8 \pm 5.30$  kg, BCS of  $2.65 \pm 0.35$  from a 5-point scale (Russell *et al.*, 1969), and age between 2 and 3 years. Ewes grazed during the daylight in paddocks of irrigated and fertilized Star grass (*Cynodon plectostachyus*) and housed overnight. Females had free access to water and mineral salts and were supplemented with 300 g of a commercial feed each day (16% crude protein; AFRC, 1993). Lambs were weighed within the first 24 h post-lambing and subsequently at weaning. During the pre-weaning period, lambs were penned in pens while ewes grazed from 7:00 h to 16:00 h. Dams and lambs were gathered in the same pen during the afternoon and night when they were returning from grazing. Weaning was performed at approximately 70 days of age. Lambs received chopped grass *ad libitum* and around 100 g of a commercial concentrate (16% crude protein) from the first week of age until weaning.

### Measurements in ewes and lambs

Data collected included ewe identity, date of lambing, ewe BW, BCS and udder type (UT), which were recorded 24 h after lambing. The BCS was measured using a 5-point scale, where BCS 1 corresponded to a very thin ewe and BCS 5 to a very fat ewe (Russell *et al.*, 1969; Thompson and Meyer, 1994). The UT was classified based on the position/insertion of teats into four types (Rovai *et al.*, 2004): type I=horizontal teats, type II=teats at 45 degrees; type III=vertical teats (most desirable for “udder machine”), and type IV=misshaped udder. In addition, ewe BW at weaning (BWW) and litter size (LS) at lambing and weaning were recorded. In the case of lamb measurements, identification, birth date and weight, weaning date and weight, sex, lambing litter weight (LBW), WLW, and age at weaning (days) were recorded.

From the information collected on ewes and lambs, both LWW adjusted at 70 days of age ( $LWW_{70} = LLW + ADG \times 70$  d) and pre-weaning average daily gain ( $ADG = [LWW - LBW] / \text{age at weaning}$ ) were calculated as criteria of ewe productivity. In addition, it was calculated different indexes of ewe productive efficiency (EEF): 1)  $EEF = WLW / \text{ewe BW at lambing}$ , 2)  $EEF^{0.75} = WLW / \text{ewe BW}^{0.75}$  at lambing, and 3)  $EEF2 = \text{ewe BW gained or lost at weaning} / \text{ewe BW at lambing}$ .

### Statistical analyses

Initially, all study variables were subjected to normality with the Shapiro Wilk test using W statistic. Then, an analysis of variance was performed fitting a lineal model with PROC

GLM of the Statistical Analysis System software, version 9.0 (SAS Institute Inc, Cary, NC, USA). The fixed effects included in the model were ewe BW, BCS, UT and litter type; all factors considering its measurement at lambing. The levels of each factor were as follows: ewe BW=high (>32.0 kg), medium (28.0 to 31.0 kg) and low (<27.2 kg); ewe BCS=high ( $\geq 3$  points) and low ( $\leq 2.5$  kg); UT=I, II, III and IV; and litter type=M (single lambing with a male), F (single lambing with a female), MM (double lambing with two males), FF (double lambing with two females) and FM (double lambing with male and female). Means were compared using the Tukey-Kramer test at  $P < 0.05$ .

## RESULTS AND DISCUSSION

Ewe BW affected ( $P < 0.05$ ) LBW, ADG and LWW, being the high BW ewes that had the heavy litter at birth and weaning (Table 1). While BCS did not affect ( $P > 0.05$ ) the study variable, UT and litter type modified ( $P < 0.05$ ) ADG, LWW70, and all productive efficiency indexes with exception of EEF2. Ewes with udder classified as type I, II and III had similar ( $P > 0.05$ ) LWW70, ADG and efficiency indexes, but all those variables had the lowest ( $P < 0.05$ ) mean values in ewes with type-IV udder (Table 2). Double litters with any combination of sexes had similar ( $P > 0.05$ ) LLW, ADG, LWW70, EEF and EEF<sup>0.75</sup>. All those variables in F single litters had lower ( $P < 0.05$ ) mean values than in double litters with FM and MM, but similar ( $P > 0.05$ ) compared to M single litters. Additionally, only

**Table 1.** Least square means and standard errors of lambs pre-weaning growth traits as a criteria of ewe productivity.

	n	LBW (kg)	ADG (kg/Day)	LWW70 (kg)
Ewe body weight		P<0.001	P<0.001	P<0.001
High	17	3.478±0.161 <sup>a</sup>	0.170±0.008 <sup>a</sup>	15.404±0.622 <sup>a</sup>
Medium	16	2.844±0.164 <sup>b</sup>	0.138±0.009 <sup>b</sup>	12.476±0.632 <sup>b</sup>
Low	15	2.410±0.190 <sup>b</sup>	0.130±0.008 <sup>b</sup>	11.566±0.730 <sup>b</sup>
Ewe body condition score		NS	NS	NS
2.5	31	3.055±0.119 <sup>a</sup>	0.143±0.005 <sup>a</sup>	13.052±0.459 <sup>a</sup>
3	17	2.766±0.175 <sup>a</sup>	0.150±0.008 <sup>a</sup>	12.245±0.672 <sup>a</sup>
Udder type		NS	P<0.001	P<0.001
I	8	2.617±0.242 <sup>a</sup>	0.171±0.011 <sup>a</sup>	14.580±0.933 <sup>a</sup>
II	19	2.850±0.201 <sup>a</sup>	0.166±0.010 <sup>a</sup>	14.445±0.773 <sup>a</sup>
III	13	3.221±0.213 <sup>a</sup>	0.186±0.010 <sup>a</sup>	16.226±0.820 <sup>a</sup>
IV	8	2.953±0.387 <sup>a</sup>	0.118±0.017 <sup>b</sup>	11.25±1.075 <sup>b</sup>
Litter Type		P<0.0001	P<0.0001	P<0.0001
F	15	1.963±0.218 <sup>a</sup>	0.105±0.011 <sup>a</sup>	9.344±0.839 <sup>a</sup>
FF	7	3.237±0.239 <sup>ab</sup>	0.148±0.012 <sup>b</sup>	14.027±0.920 <sup>b</sup>
M	12	2.236±0.231 <sup>a</sup>	0.123±0.011 <sup>ab</sup>	10.848±0.891 <sup>ab</sup>
FM	8	3.621±0.328 <sup>b</sup>	0.153±0.012 <sup>b</sup>	14.152±0.922 <sup>b</sup>
MM	6	3.495±0.563 <sup>b</sup>	0.202±0.017 <sup>b</sup>	17.370±1.167 <sup>b</sup>

LWB=Litter weight at birth (kg), LWW70=Litter weight at weaning adjusted at 70 days, ADG: average daily gain of lambs (g/d. Means with different superscript indicated statistical differences ( $P < 0.05$ ).

ADG and WLW70 were different ( $P < 0.05$ ) between F single and FF double litters, being higher in the latter.

Knowledge about environmental factors affecting pre-weaning performance of lambs is useful to modify and/or propose feeding and handling strategies in lambs, which could optimize productive efficiency (Oliva-Hernández and García-Osorio, 2016). However, there are few studies related to these factors in hair sheep. Although the current study included a low number of animals, results partially support the hypothesis as ewe BW, UT and litter size modified lamb pre-weaning growth, and this was reflected on ewe productivity and efficiency. The BCS was not a predisposing factor for lamb pre-weaning growth and ewe productive efficiency.

Results of the present study showed that heavier ewes at lambing had 45 and 28% more litter weights at birth and weaning, respectively, compared to low BW ewes. It has been reported that maternal BW is a very important characteristic in animal husbandry, since increases in dam BW improves reproduction efficiency and profitability in ewes (Cam *et al.*, 2010; Aliyari *et al.*, 2012; Benchohra *et al.*, 2015). In Rembi ewes, Benchohra *et al.* (2015) reported that heavier ewes at lambing produced 10.26% more milk than lightweight ewes. This finding is relevant as high daily milk yield is related with high pre-weaning ADG and finally weaning weight in offspring (Ünal *et al.*, 2008; Sezenler *et al.*, 2016). Although milk production was not measured in the current study, results from LWW70 and ADG due to ewe BW at lambing were attributed to this fact. In line with our results, Hinojosa-Cuellar *et al.* (2019) found that the ewe BW at lambing affected the pre-weaning performance in hair lambs raised under tropical production systems, being heavier at birth and weaning lambs born from ewes with high BW at lambing.

With regard to ewe BW on productivity, the trend found in the current study is similar to those reported by Segura-Correa *et al.* (1996), when studying the productivity of Pelibuey and Blackbelly sheep under extensive management conditions in Mexico, reported lower productivity and prolificacy in ewes with lower BW than the average BW of the group. Overall, results of ewe productivity agree with those reported for Katahdin and Pelibuey breed ewes kept in tropical conditions of Mexico (Nasrat *et al.*, 2016; Chay-Canul *et al.*, 2019). On the other hand, with regard to the effect of BCS on the lamb pre-weaning performance, Kenyon *et al.* (2014) reported that ewe BCS has no influence on pre-weaning ADG and weaning weight in lambs. These results are similar to ours. In Romney breed, ewes with a BCS of 3.5-4.0 at breeding had lambed lighter offspring than ewes with a BCS of 3.0. (Kenyon *et al.*, 2004). However, in the study of Cranston *et al.* (2017), the ewe BCS had no effect on lamb birth weight, which is congruent with our results. Sezenler *et al.* (2016) and Cranston *et al.* (2017) suggested that controlling maternal BCS ( $BCS > 2.0$ ) in late pregnancy and early lactation may increase milk production and consequently to improve both ewe and lamb performance at weaning.

Several authors have reported that udder characteristics do not belong to the most important traits of the lactating sheep, but they could have strong effects on the milk yield and composition, and consequently lamb growth rate (Ugarte and Gabina 2004; Sezenler *et al.*, 2016). Sezenler *et al.* (2016) stated that the relationships among morphological udder

**Table 2.** Least square means and standard errors of ewe efficiency.

	n	EEF	EEF <sup>0.75</sup>	EEF2
Ewe body weight		NS	NS	NS
High	17	0.431±0.020 <sup>a</sup>	1.055±0.046 <sup>a</sup>	0.490±0.031 <sup>a</sup>
Medium	16	0.407±0.020 <sup>a</sup>	0.958±0.046 <sup>a</sup>	0.476±0.037 <sup>a</sup>
Low	15	0.448±0.023 <sup>a</sup>	1.009±0.054 <sup>a</sup>	0.498±0.036 <sup>a</sup>
Ewe body condition score		NS	NS	NS
2.5	31	0.438±0.014 <sup>a</sup>	1.021±0.034	0.499±0.023
3	17	0.420±0.021 <sup>a</sup>	0.994±0.049	0.477±0.034
Udder type		P<0.01	P<0.01	NS
I	8	0.456±0.029 <sup>a</sup>	1.081±0.068 <sup>a</sup>	0.507±0.046 <sup>a</sup>
II	19	0.478±0.024 <sup>a</sup>	1.117±0.057 <sup>a</sup>	0.517±0.038 <sup>a</sup>
III	13	0.517±0.026 <sup>a</sup>	1.224±0.060 <sup>a</sup>	0.603±0.040 <sup>a</sup>
IV	8	0.358±0.039 <sup>b</sup>	0.788±0.078 <sup>b</sup>	0.428±0.052 <sup>a</sup>
Little Type		P<0.001	P<0.001	NS
F	15	0.324±0.026 <sup>a</sup>	0.748±0.061 <sup>a</sup>	0.385±0.041 <sup>a</sup>
FF	7	0.439±0.040 <sup>ab</sup>	1.045±0.092 <sup>ab</sup>	0.513±0.046 <sup>a</sup>
M	12	0.378±0.028 <sup>a</sup>	0.873±0.065 <sup>a</sup>	0.412±0.045 <sup>a</sup>
FM	8	0.454±0.029 <sup>b</sup>	1.070±0.067 <sup>b</sup>	0.530±0.064 <sup>a</sup>
MM	6	0.548±0.048 <sup>b</sup>	1.299±0.109 <sup>b</sup>	0.596±0.089 <sup>a</sup>

EEF: Calculated as (LWW70)/BW of ewe at lambing); EEF<sup>0.75</sup>: Calculated as (LWW70)/ BW<sup>0.75</sup> of ewe at lambing; EEF2: expressed as kg of lamb weaned ± ewe BW gained or lost at weaning per kg ewe BW at lambing. Means with different superscript indicated statistical differences (P<0.05).

traits would permit to predict future correlated responses in milk-oriented selection schemes in sheep. To date, in Pelibuey sheep, few studies have evaluated udder morphological traits and their relationship with milk yield (Arcos-Alvarez *et al.*, 2020; Espinoza-Mendoza *et al.*, 2020) and performance of suckling lambs (Chay-Canul *et al.*, 2021). In the present study, it was observed that lambs had a similar LLW in ewes scored in different udder types. However, lambs from dams with udder scores from I to III had higher ADG by almost 57% compared to lambs from ewes with type-IV udder; this was reflected in 47% more WLW70 for ewes with type-I, II and III udders. With regard to prolificacy, several studies indicated that ewes rearing twin lambs had higher productive efficiency compared with single bearing ewes. Chay-Canul *et al.* (2019) reported that WLW70 and EEF were similar between Katahdin and Pelibuey with single- or twin-bearing ewes. In addition, the authors mentioned that both ewe productivity and efficiency are better for twin-bearing ewes than for single-bearing ewes, regardless of genotype. These results agree with the present study.

Overall, when productive efficiency was evaluated, ewes with double litter (MM and MF) were more productive based on live and metabolic BW compared to ewes with F single litter. However, this difference disappeared when efficiency index was obtained using ewe BW change across the pre-weaning period. These findings suggest that Pelibuey ewes efficiently using energy consumed for meat production, either in the form of weaning

lamb kilograms or in the accumulation of its body reserves. Therefore, the efficiency of Pelibuey ewes should be evaluated considering the productivity (litter weight) associated with the intrapartum period.

## CONCLUSIONS

Overall, ewe BW at lambing, position/insertion of the teats into the udder and litter type (sex and prolificacy) are factors controlling the offspring pre-weaning growth, as well as the ewe productivity and efficiency at lambing and weaning in Pelibuey ewes reared in tropical production systems. Given that farmers want greater productive efficiency at weaning, heavy Pelibuey ewes with non-misshapen udders and double litters could be of optimal maternal characteristics.

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