



SHORT COMMUNICATION

Milk yield and composition of Katahdin and Pelibuey ewes in tropical conditions

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ABSTRACT. Pelibuey and Katahdin are two the most extensively used hair sheep breeds in tropical regions characterized by high temperatures and humidity. Lactation influences profitability of sheep in dairy and non-dairy production systems. Therefore, the aim of this study was to evaluate the effect of breed and litter size (LS) on milk yield and milk composition of Pelibuey ($n = 28$) and Katahdin ($n = 21$) ewes reared under tropical conditions of Mexico. Milk, fat, protein and lactose yields, fat and energy-corrected milk, and fat, protein and lactose percentages were measured for seven weeks. Body weight (BW) of each ewe was measured weekly. Breed effects were significant ($P < 0.001$) favouring Katahdin breed on all yield traits. Ewes rearing two lambs had higher yields ($P < 0.01$) for all traits than ewes rearing one lamb. Fat percentage and BW were significantly ($P < 0.05$) affected by a triple interaction effect of Breed x LS x Week. So, important differences in milk yield and composition among breeds and LS were shown and might be considered in order to improve profitability of sheep production systems under tropical conditions.

Introduction

In all production systems, milk yield of the dam is a determinant of good performance and early growth of young animals (Morgan et al., 2016). During the first weeks of lamb life, growth depends completely on the ewe milk, until it can eat solid feeds such like concentrates and pasture. Increased ewe productivity, which is determined by litter sizes and lamb growth rates, can improve the profitability of lamb production systems.

In some studies the effect of quantity and quality of milk supply during pre-weaning period on the growth and feed conversion efficiency of lambs after weaning was reported (Danso et al., 2016). The estimation of milk yield contributes a valuable information needed to implement management strategies both for ewes and their lamb as the milk yield influences weaning weight and variations in milking ability among breeds and genetic groups available in tropical areas (Peniche-Gonzalez et al., 2015).

Pelibuey and Katahdin breeds, are currently extensively used in different regions of Mexico. Pelibuey is the most popular sheep breed as it exhibits non-seasonal reproduction characteristics, rusticity, prolificacy and high tolerance to parasites (Aguilar-Martínez et al., 2017). Similarly, Katahdin, a breed created by crossbreeding from different Caribbean tropical breeds with British breeds (Wildeus, 1997), has been extensively used as pure-bred sheep and also as an animal for crossbreeding purposes and dispersed throughout all regions of Mexico since its introduction from USA. Unfortunately, there is a limited number of studies reporting the milk yield and milk composition of these breeds under tropical conditions of Mexico. This information might be useful to design feeding systems aimed to sustain the nutrient requirements for ewes needed to obtain optimal pre-weaning lamb growth and body recovering of the ewe after weaning. So, the objective of the study was to evaluate milk composition and milk production indicators of Pelibuey and Katahdin ewes rearing one or two lambs.

Material and methods

Experimental design

Animals were managed in accordance to the guidelines and regulations for ethical animal experimentation of Academic Division of Agricultural Sciences of Juarez Autonomous University of Tabasco, and approved as a project: PFI: UJAT-DACA-2015-IA-02. The animals were kept at the 'El Rodeo' farm, located at 17° 84' N latitude and 92°81' W longitude, Tabasco State, Mexico, with an average temperature of 28 °C and 63 mm of rainfall during the experimental months, with extremes of relative humidity between 54–95%. In the study 2–3 year-old Pelibuey (n = 28) and Katahdin (n = 21) ewes lambing during March 2016 were used. Animal mean body weight (BW) was 45.43 ± 6.80 kg.

Management of animals

After lambing, each ewe and their offspring were maintained and managed under a feedlot system in individual pens for 49 days, with free access to feed and water. Ewes were dewormed with 0.2 mg/kg BW of Cydectin NF® (Pfizer, New York, NY, USA). Animals were fed star grass hay (*Cynodon nlemfuensis*), soybean meal, ground maize sugarcane molasses and minerals, with an estimated metabolizable energy of 12 MJ/kg dry matter (DM) and 15% crude protein (CP) (AFRC, 1993). Each week animals BW was measured and the amount of feed offered to

each ewe was adjusted weekly according to BW. The diet was formulated according to AFRC guidelines (AFRC 1993) for ewes with 45 kg mean BW producing 1.74 kg milk/day with 7% fat and 4.5% CP.

Lamb milk consumption was determined every week by the weigh-suckle-weight (WSW) method as described previously by Peniche-González et al. (2015). Lamb BW (kg) were measured every week from the first week of the experiment until day 49 (7 weeks). The WSW method involved a weekly lamb separation from the dam starting at 3:00, lasting for 3 h, and then suckling for 10 min at 6:00. Next, lambs were again separated from ewes after suckling (at 9:00, 12:00, 15:00 and 18:00) and put in pens that allowed sight and smell contact with their dams but avoided suckling. The difference between pre- and post-suckling weight was defined as milk consumption. Daily milk yield (MY, kg) of ewes at the week of measurement was calculated by the total of the estimations recorded during the 12 h period and multiplying by two (Peniche-González et al., 2015).

Milk composition

Ewes were hand-milked every week (the day after estimation of MY) in the morning after previous injection of 3 IU of Oxitocin (Pisa, Mexico) and samples of 100 ml were used for milk composition analysis. Analyses of fat, protein and lactose percentage were performed by duplicate using an automatic milk analyser (Lactoscan LS-60, Milkotronic Ltd., Nova Zagora, Bulgaria). The equipment was calibrated for fat by the Gerber method and for protein by a total nitrogen determination, according to the Dumas method using a LECO CNS-2000 series 3740 analyser (LECO Corp. St. Joseph, MI, USA). Daily yields of fat (FY), protein (PY) and lactose (LY) were calculated by multiplying the MY by corresponding percentages. Energy-corrected milk yield (ECM, kg) was calculated according to formula of Sjaunja et al. (1990):

$$ECM = MY \times \left\{ \frac{[(38.3 \times FY) + (24.2 \times PY) + 783.2]}{3140} \right\}.$$

Statistical analyses

All dependent variables were analysed using a mixed linear model for repeated measures, with the following model:

$$y_{ijkl} = \mu + B_i + LS_k + W_l + BL_{ik} + \beta x_{ijk} + \alpha_j + \varepsilon_{ijkl} (a)$$

where: y_{ijkl} – evaluated trait, μ – overall mean, B_i – fixed effect of the i_{th} breed (Pelibuey or Katahdin), LS_k – fixed effect of the k_{th} litter size (single or twin), W_l – fixed effect of l^{th} week of lactation (1, 2, ..., 7), BL_{ik} – interaction between breed and

litter size, an alternative model replacing described interaction by Breed \times LS \times Week of lactation was also fitted, β – regression coefficient of initial trait x_{ijkl} affecting the record y_{ijkl} , α_j – random effect of the j^{th} ewe, and ε_{ijkl} – random error associated with the y_{ijkl} record.

It was assumed that:

$$E(y_{ijkl}) = \mu + B_i + W_k + L_l + BWS_{ikl} + \beta x_{ijkl}, \quad (b)$$

$$Var(\alpha_j) = \sigma_a^2 \text{ and } Cov(\varepsilon_{ijkl}, \varepsilon_{i'j'k'l'}) = \mathbf{R}$$

Based on the Akaike Information Criterion a compound symmetry covariance structure was selected as the best structure to model the matrix \mathbf{R} to account for repeated measures on the same animal. Least-squares means for fixed effects were obtained

and used for multiple mean comparisons with a Bonferroni adjustment. All statistical procedures were performed using the statistical computer package SAS 9.3 (SAS Institute Inc., Cary, NC, USA).

Results

Least-squares means for BW and milk traits for breeds and LS and their interaction are presented in Table 1. Effects of breed and LS were significant for all daily yield traits ($P < 0.01$). Conversely, no significant effect of these factors on BW and milk composition traits was present. Interaction between breed and LS was not significant for any of the traits ($P > 0.05$). Katahdin ewes rearing one and two lambs yielded 16 and 23 g more protein and fat per day of

Table 1. Least-squares means (\pm SE) for body weight and milk yield and composition traits of Pelibuey and Katahdin ewes rearing single and twin lambs under tropical conditions of Mexico.

Trait	Breed		Litter size		Pelibuey		Katahdin	
	pelibuey	katahdin	singleton	twin	singleton	twin	singleton	twin
Body weight, kg	46.5 \pm 1.27	44.4 \pm 1.49	44.9 \pm 1.14	46.0 \pm 1.59	44.5 \pm 1.52	48.6 \pm 2.04	45.43 \pm 1.72	43.4 \pm 2.43
Daily yields								
milk, kg	1.44 \pm 0.05 ^b	1.77 \pm 0.06 ^a	1.30 \pm 0.04 ^b	1.91 \pm 0.06 ^a	1.19 \pm 0.06 ^z	1.69 \pm 0.08 ^x	1.42 \pm 0.07 ^y	2.13 \pm 0.10 ^w
fat, g	84.1 \pm 4.68 ^b	107.2 \pm 5.21 ^a	82.4 \pm 4.07 ^b	108.9 \pm 5.65 ^a	76.9 \pm 5.53 ^y	91.4 \pm 7.29 ^x	87.9 \pm 5.95 ^x	126.5 \pm 8.53 ^w
protein, g	73.1 \pm 2.92 ^b	89.2 \pm 3.29 ^a	66.9 \pm 2.56 ^b	95.4 \pm 3.56 ^a	60.0 \pm 3.46 ^z	86.2 \pm 4.59 ^x	73.8 \pm 3.77 ^y	104.8 \pm 5.39 ^w
lactose, g	71.5 \pm 2.80 ^b	87.8 \pm 3.16 ^a	65.9 \pm 2.47 ^b	93.5 \pm 3.42 ^a	59.2 \pm 3.32 ^y	83.8 \pm 4.41 ^x	72.6 \pm 3.62 ^x	103.1 \pm 5.18 ^w
ECM, kg	1.93 \pm 0.08 ^b	2.40 \pm 0.10 ^a	1.84 \pm 0.07 ^b	2.49 \pm 0.10 ^a	1.68 \pm 0.10 ^y	2.18 \pm 0.13 ^x	2.00 \pm 0.11 ^x	2.80 \pm 0.15 ^w
Composition, %								
fat	6.0 \pm 0.21	6.3 \pm 0.25	6.4 \pm 0.19	5.9 \pm 0.27	6.5 \pm 0.26	5.5 \pm 0.34	6.2 \pm 0.29	6.3 \pm 0.41
protein	5.0 \pm 0.31	5.1 \pm 0.04	5.0 \pm 0.03	5.1 \pm 0.04	4.9 \pm 0.04	5.1 \pm 0.05	5.1 \pm 0.04	5.1 \pm 0.06
lactose	4.9 \pm 0.04	5.0 \pm 0.04	4.9 \pm 0.03	5.0 \pm 0.05	4.9 \pm 0.05	4.9 \pm 0.06	5.0 \pm 0.05	5.0 \pm 0.07

ECM – energy corrected milk, SE – standard error, ^{ab} – means with different superscripts within one effect are significantly different at $P < 0.05$, ^{wxyz} – means with different superscripts are significantly different at $P < 0.05$

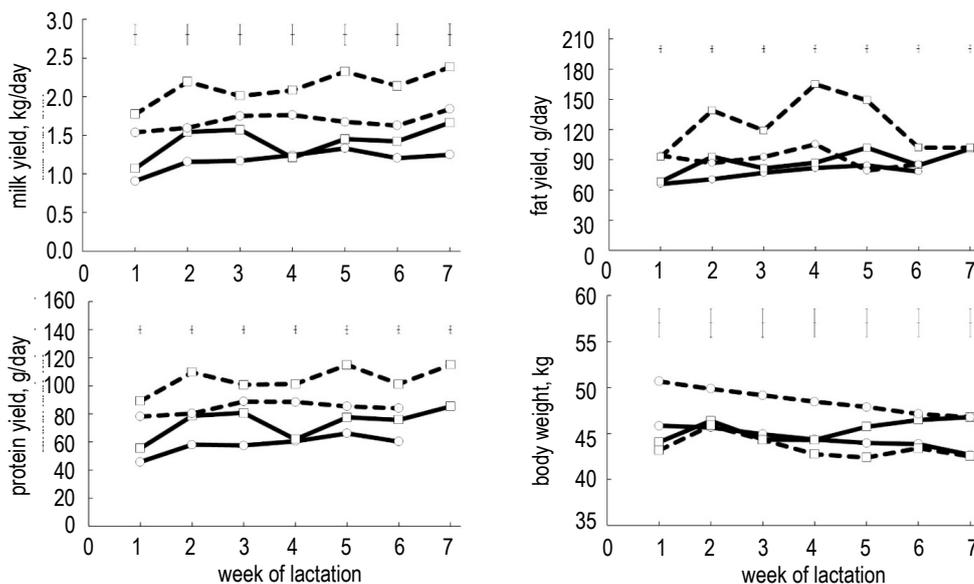


Figure 1. Daily yields of milk, fat and protein, and body weight of Pelibuey (\circ) and Katahdin (\square) ewes by singleton (—) and twin litter size (---) during seven weeks of lactation. Means are presented as pooled standard error.

lactation, respectively, in comparison to Pelibuey ewes. Ewes rearing two lambs produced from 25 to 32% more ($P < 0.05$) milk and component yields than ewes rearing one lamb (Table 1). The interaction between breed and LS was not significant. Katahdin ewes rearing two lambs produced the highest yields of milk and milk constituents resulting in the highest yield of ECM. Katahdin ewes rearing one lamb produced similar yields of milk, milk components and ECM in comparison to Pelibuey ewes rearing two lambs (Table 1).

In the present study, Katahdin ewes were characterised by a higher milk performance and milk constituents yield in comparison to Pelibuey ewes but had similar fat and protein percentages during the 7-week experiment. In contrast to dairy sheep breeds characterised by long lactating periods, non-dairy breeds and hair sheep breeds, such like Katahdin and Pelibuey, during the shorter lactating period provide optimal nutrition for their lambs. However, Katahdin ewes produced higher amount of milk and milk constituents than Pelibuey ewes with similar protein and fat percentage.

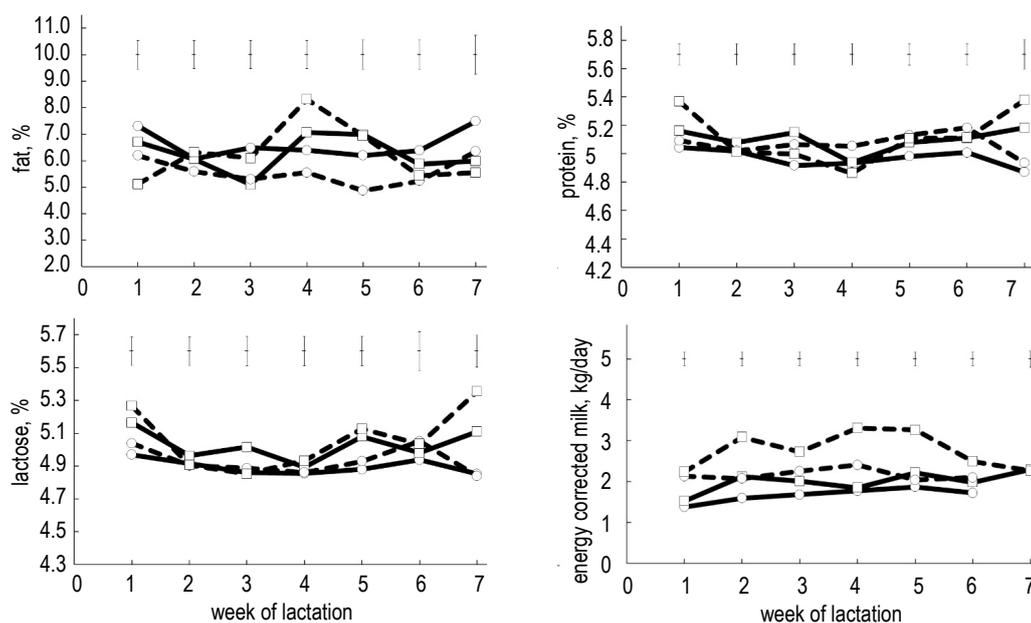


Figure 2. Percentages of fat, protein and lactose, and daily yield of fat-corrected milk of Pelibuey (\circ) and Katahdin (\square) ewes by single (—) and twin litter sizes (- -) during seven weeks of lactation. Means are presented as pooled standard error.

Discussion

Breed effect is one of the most important variations affecting milk yield and milk composition. The milk performance of the hair sheep breeds considered in this study was presented only in few studies. Burgos-González et al. (2018), reported an average of 1.38 l milk/day of Katahdin ewes managed in a subtropical environment, slightly lower than the mean value estimated in this study (1.77 kg/day). Average milk production of Pelibuey and Pelibuey crosses in Cuba was lower than the mean value of milk production of Pelibuey ewes used in our study (Pavón et al., 1987). Similarly, lower averages (around 1.1 kg/day) of milk production were reported by Peniche-González et al. (2015), estimated in a Pelibuey \times Katahdin group of ewes in Yucatan, Mexico.

In the present study, due to tropical conditions the experimental design assumed an early weaning plan (separation of lambs from ewes 60 days after lambing) in order to avoid extreme loss of corporal condition of the ewe (García and Oliva, 2016). Comparing the performance of the two breeds used in the study, it can be seen that early weaning was more profitable for Pelibuey ewes that comparatively showed more weight loss. The triple interaction Breed \times LS \times Week was significant since Pelibuey ewes rearing twin lambs at the beginning of the study were the heaviest, however a pronounced decline of their weight was observed through the 7-week experimental period. On the other hand, it was revealed that Katahdin ewes can achieve good production levels and maintain the body weight for a longer time than Pelibuey ewes. In the economic point of view, longer weaning

periods ensure healthy and heavy lambs at weaning (García and Oliva, 2016), which positively influences the final producer income.

Another positive financial aspect for producers can be seen in milking levels presented in our study. Although not conventionally for tropical region of Mexico, apparently longer lactations and production were observed. Castellanos and Valencia (1982) evaluated milk production and composition of Pelibuey ewes from Yucatan and proposed a dual-purpose management for milk and cheese production using milk solid composition and large proportion of fat, and better acceptability than cow milk products. As for international markets milk solids are important, this potential ability needs to be taken into consideration, especially by the producers focused on harvesting.

On the other hand, it was indicated that, at the beginning of lactation and regardless of breed, ewes rearing twin lambs were heavier, had higher daily MY with similar percentages of fat and protein than animals rearing only one lamb. Ewes rearing twin lambs produced more accumulated MY than ewes rearing one lamb. Similarly to the results of Morgan et al. (2016), MY peak in ewes rearing two lambs was around second and fourth week of lactation.

The ewe MY performance is directly related to the suckling stimulus of litter size, determining the subsequent full secretion through the course of lactation (Rosales et al., 2018). It was previously reported that the intensity of suckling has a hormonal basis present since the postpartum, through the exposure of oestrogen, progesterone, placental lactogen and oxytocin stimulating mammaryogenesis and lactogenesis of the ewe, which as a consequence can be observed as high placental weight and foetal growth (Selvaggi et al., 2016). Additionally, Marnet and Negrão (2000) indicated that two or more lambs suckle for a longer time than one lamb, and therefore longer teat stimulation increases the release of oxytocin and prolactin secretions in dams.

The number of lambs born from the one ewe influences the quality of milk – higher milk fat percentages were noted in ewes rearing twins than in those rearing one lamb (Snowder and Glimp, 1991). Also, tropical conditions can influence percentage of milk total solids: the more lambs are reared by the ewe the more total solids are present in the milk (Macedo et al., 2012).

These findings support the high potential of the ewe mammary gland which is necessary to obtain satisfactory lamb growth, so important in sheep production systems used in tropics. It was previously

found that MY and composition explained most of variations in the Romney twin lambs growth during the first 42 days of suckling (Danso et al., 2016), suggesting that the selection of ewes with higher MY could maximize the lamb growth before weaning. Therefore, the consideration of MY and composition potentials of some breeds can influence the profitability of productive systems under humid tropical conditions. This strategy could be accompanied with an appropriate feeding of ewes resulting in an optimal pre-weaning lamb growth and immediate recovery of ewe post-weaning.

Conclusions

In humid tropical conditions lactating Katahdin ewes had higher milk yield and better production performance than Pelibuey ones. However, the milk composition between these two breeds was similar. Ewes rearing twin lambs had higher milk yields, milk components and energy-corrected milk indices. Early weaning could be a recommended milking management for Pelibuey ewes; only when postweaning lamb feeding and health management is improved to ensure high survival rate, optimal lamb growth post weaning, and body weight recovering of the ewe.

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