



Reproductive and fertility parameters of ewes from the Colombian tropical highlands

Parámetros reproductivos y de fertilidad de ovejas en el trópico alto de Colombia

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ABSTRACT

Two studies were conducted on sheep in the high tropics of Colombia to study reproductive and fertility parameters associated with animal growth in this ecological zone. In the first trial, 1,389 records were used to analyze, through descriptive statistics, the fertility parameters, the birth rate, and the yield per multiple births of three genetic groups of sheep: the native Criolla and Manchada Paramuna breeds, and they were compared with the imported race Blackface. In the second study, the duration of the estrous cycle was determined and serum progesterone values were determined during the estrous cycle in 19 Criolla x Romney Marsh crossbred ewes, in this experiment, five moments of the cycle were analyzed. The fertility rates found in the Criolla and Manchada Paramuna breeds were 73.1 and 72 %, respectively, and were higher than those of the Blackface sheep (65 %). Blackface ewes showed the highest incidence of multiple births (29 %) and Manchada Paramuna ewes had the highest birth rates (93.7 %). Criolla x Romney Marsh crossbred ewes recorded a mean duration of the estrous cycle of 17.8 d. The highest progesterone secretion (11.5 nmol/L) occurred on day 9 of the estrous cycle, while in the estrus phases, its value was 0.32 nmol/L. This study contributes to the knowledge of the reproductive aspects of Colombian native sheep.

Keywords: Estrous cycle; Ovine; Native breeds; Progesterone; Reproductive performance.

RESUMEN

Se realizaron dos estudios en ovejas en el trópico alto de Colombia, para estudiar los parámetros reproductivos y de fertilidad asociados con el crecimiento animal, en esta zona ecológica. En el primer ensayo, se utilizaron 1.389 registros para analizar, a través de estadísticas descriptivas, los parámetros de fertilidad, la tasa de natalidad y el rendimiento por parto múltiple, de tres grupos genéticos de ovejas: las razas nativas Criolla y Manchada Paramuna y se compararon con la raza importada Blackface. En el segundo estudio, se determinó la duración del ciclo estral y se determinaron valores de progesterona sérica durante el ciclo estral, en 19 ovejas cruzadas Criolla x Romney Marsh; en este experimento, se analizaron cinco momentos del ciclo. Las tasas de fertilidad encontradas en las razas Criolla y Manchada Paramuna fue de 73,1 y 72 %, respectivamente, superior a la de las ovejas Blackface (65 %). Las ovejas Blackface mostraron la mayor incidencia de partos múltiples (29 %) y las ovejas Manchada Paramuna tuvieron las tasas de parto más altas (93,7 %). Las ovejas cruzadas Criolla x Romney Marsh registraron una duración media del ciclo estral de 17,8 d. La mayor secreción de progesterona (11,5 nmol/L) ocurrió

el día 9 del ciclo estral, mientras que en las fases del estro, su valor fue de 0,32 nmol/L. Este estudio contribuye con el conocimiento de los aspectos reproductivos de las ovejas nativas colombianas.

Palabras clave: Ciclo estral; Ovinos; Progesterona; Razas nativas; Rendimiento reproductivo.

INTRODUCTION

The ovine population in Colombia is approximately 1,629,000 animals. From this population, 87.57 % is distributed in the departments of La Guajira 41.38 %, Magdalena 11.56 %, Boyacá 7.75 %, Cesar 7.69 %, Córdoba 6.42 %, Santander 3.33 %, Sucre 2.57 %, Bolívar 2.35 %, Meta 2.34 % and Cundinamarca 2.20 % (ICA, 2019). Predominant breeds are Criolla 64 %, followed by European breeds and native crossbred sheep 31.3 %. Only 5 % of the wool sheep are of pure breeds like Romney Marsh, Corriedale, Blackface, Merino-Rambouillet, and Cheviot (Caja Agraria, 1986; Moreno & Grajales, 2017).

The information on sheep production systems in the high tropics of Colombia is scarce. Given the current dynamics of the sector, it is important to know studies and current and historical references,

as a way of promoting the adaptation and importance of heterosis studies in native ewes' breeds, reproductive performance and biotechnologies use for improvement projects (Payares-Luna *et al.* 2018; Conde Silva *et al.* 2017).

In this context, is important to mention the difference between breeds' seasonal polyestrous activity associated with photoperiod. Ewes of European origin show activity linked to a decreased photoperiod (Gavojdian *et al.* 2015). In Colombia, the maximum daily photoperiod variation is about 35 minutes (McNutt *et al.* 2019), Romney Marsh ewes at 3000 m a.s.l. have sexual activity throughout the year (Lozano-González *et al.* 2012).

In the past decades, different studies conducted on ewes in the tropics have shown that there is not a clear-cut anestrus period and that the sexual activity of these animals is mainly affected by other factors such as health, nutrition, temperature, and rainfall (Rodríguez, 1989; Luna-Palomera *et al.* 2019). Studies on the reproductive performance of different breeds of ewes in Colombia have shown that Criolla and Criolla x European crossbred ewes have better rates of fertility and lambing than European breeds (Table 1).

Table 1. Fertility and lambing rates in ewes from Colombian tropical highlands reported in several studies.

Breed	Fertility (%)	Birth rate (%)	Reference
Blackface	60.8	80.9	Fernández & Useche (1981)
Cheviot	84.0	-	Pastrana (1975)
Romney Marsh	80.4	83.0	Alderson <i>et al.</i> (1988)
Corriedale	-	78.0	Alderson <i>et al.</i> (1988)
Rambouillet	-	70.0	Alderson <i>et al.</i> (1988)
Manchada Paramuna	79.2	93.0	Pérez & Pulido (1989)
Criolla	84.7	89.5	Fernández & Useche (1981)
Blackface x Criolla	96.0	88.0	Pérez & Pulido (1989)

Most sheep breeds' in this region have estrous cycle lengths between 14 and 19 days (Gavojdian *et al.* 2015). Wool sheep, like Merino and Rambouillet, have cycles one day longer than other breeds (Ferguson *et al.* 2011). Also, in those breeds, 5 to 10 % of the animals may have estrous cycles longer than 21 days (Quirke *et al.* 1985).

For the study of the estrous cycle, it has also been analyzed in addition to progesterone, and estrogens in feces, giving good information about the reproductive behavior in sheep (Amaral *et al.* 2019).

This study aims to assess historical reproductive performance (fertility, birth, and multiple lambing rates) in ewes of European origin and native breeds of the tropical highlands of Colombia, and to determine estrous cycle length and progesterone secretion in crossbred ewes.

MATERIALS AND METHODS

For this study, two types of analysis were performed: in the first work, data on the ovine creoles breeds Manchada Paramuna, and Criolla were employed. Additionally, this information was compared with ewe's Black face an imported breed. In the second work, an experimental process for determining blood progesterone concentration and duration of the estrus cycle in crossbred ewes was done.

First Study. Records of reproductive performance of two ovine flocks during three years were used. The farms are located in the Eastern Cordillera of Colombian Andes highlands, at 3200 m a.s.l. with a mean annual temperature of 10 °C. The mean annual rainfall in this area varies from 1.000 to 1.500 mm and the relative humidity ranges from 80 to 85 %. The animals grazed extensive pasture year-round. The predominant forages were *Pennisetum clandestinum* Hoehst Ex Chiov (Correa C. *et al.* 2008) and *Holcus lanatus* L. in 80 % of the cases, with variable proportions of *Anthoxanthum*

odoratum L., *Dactylis glomerata* L. and *Trifolium repens* L. Water and mineralized salt were supplied *ad libitum*.

Reproductive records from 913 Blackface ewes (three years), 383 Manchada Paramuna ewes (one year), and 93 Criolla ewes, (one year) were utilized, to determine the following parameters: fertility rate (number of lambing/ewes exposed to rams); lambing rate (number of lambs born /ewes exposed to rams); multiple lambing rate (number of twin lambing/number of total lambing). Also, it was considered the bodyweight of the ewes, the newborn, and the weaned lambs, as well as the lamb mortality rate recorded at weaning (3,5-month-old lambs). Bodyweight data of Manchada Paramuna ewes were not available. Reproductive husbandry included a single mating period of 51 days starting in November. Lambing occurred in March-April, weaning in June-July, shearing in August, and selection of ewes for next mating in September.

All data were analyzed using descriptive statistics measures of central tendency and dispersions. Analysis of variance was used to determine differences in rates (fertility, lambing, multiple lambing, and lamb mortality) among breed groups and body weights.

Second study. This work was conducted at the Eastern Cordillera of Colombian Andes highlands in the Sabana de Bogotá zone, located at 2.640 m above sea level, with an annual mean temperature of 12 °C, relative humidity of 79 %, and a mean annual rainfall of 938 mm.

Nineteen crossbred Criolla x Romney Marsh ewes 12 to 36 -month-old were used. Ewes grazed pastures of *Pennisetum clandestinum* from July to February. The ewes received mineralized salt *ad libitum*

and 150 g/day of a concentrate containing 14 % protein and 65 % TDN. All ewes were observed daily (in a total of 23 estrous cycles) for estrous behavior in two,30-minute periods at 07:00 and 18:00 using a vasectomized ram and an androgenized ewe.

Blood samples were obtained of the jugular vein on five days: 0 (estrous), 4, 9, 14, and 17 day of the estrous cycles using *vacutainer* plain tubes. Blood samples were centrifuged after 4h of collection for obtaining serum, which was frozen (-20 °C) until progesterone analysis (solid-phase radioimmunoassay, Diagnostic Products Co., Los Angeles, CA). The progesterone concentration calculated was realized by RiaCalc of Guelph University. Mean and standard deviation of serum progesterone values were determined for the entire estrous period.

RESULTS AND DISCUSSION

The study developed in the Colombian highlands, involving two ovine flocks, showed that the Criolla ewes had a higher fertility rate when compared to breeds like Manchada Paramuna and Blackface; this contrasted with the lambing rate that was higher in Manchada Paramuna. This depicts similar results presented in previous studies on the subject, as it usually presents one adaptation characteristic in native species in tropical conditions (Marai *et al.* 2007).

The fertility rate product of climatic adaptation was higher in Criolla ewes and Manchada Paramuna ewes than in Blackface ewes. The lambing rate was greater in Manchada Paramuna ewes than in the other two breeds of ewes. Multiple lambing rate was similar in Manchada Paramuna and Blackface ewes and greater than in Criolla ewes (Table 2).

Table 2. Productive and reproductive performance of native ewes' Manchada Paramuna and Criolla, compare with the imported breed Blackface, in the Colombian tropical highlands.

Parameter	Manchada Paramuna	Criolla	Blackface
N° of ewes	383	93	913
Fertility rate (%)	72.0 ^a	73.1 ^a	65.0 ^b
Lambing rate (%)	93.7 ^a	82.8 ^b	82.7 ^b
Multiple lambing rate (%)	29.0 ^a	11.7 ^b	28.6 ^a
Body weight of ewes at mating (kg)	-	34.1 ^b ±6.8	52.1 ^a ± 15
Body weight of lambs at lambing (kg)	-	3.8 ^b ±0.6	4.4 ^a ± 0.8
Body weight of lambs at weaning (kg)	-	22.3±3.1	25.7 ± 6,9
Mortality rate of lambs at weaning* (%)	5.6 ^c	13.0 ^a	7.4 ^b

* 3-3,5-month-old, Values with different letters among breeds differ significantly (P <0,05).

Regarding body weight, some authors mention that the highest weights for adult females are found in purebreds (Pérez & Pulido, 1989). The present study showed that the Criolla ewes and lambs had lower body weight than Blackface, reinforcing the concept that the Criolla ewe is considered a small breed (Ocampo *et al.* 2017) (Table 2).

The mean length of the estrous cycle in Criolla x Romney Marsh ewes was 17.8 ± 1.7 days with a range of 15 to 21 days. Serum

progesterone levels were 0.35 ± 0.16 nmol/L an estrous day (day 0 of the cycle), then raised to 3.2 ± 0.64 nmol/L on day 4 of the cycle, 11.52 ± 5.12 nmol/L on day 9, 10.9 ± 4.48 on day 14, in the day 17 of the cycle the progesterone concentration was 0.32 ± 0.13 nmol/L.

The occurrence of multiple births found in this study was nearly 29 %, which was similar to that described by Pérez & Pulido (1989), in Manchada Paramuna and Blackface breeds. Values of

this parameter for Criolla ewes was 11.7 %, which is higher than the value reported by Pérez & Pulido (1989) of about 5 %. Other studies reported similar values in the Sabana of Bogotá ecological zone (Cuéllar-Gamboia *et al.* 2015).

The present results concur with other authors such as Fernández & Useche (1981), who suggested that native Colombian breeds (Criolla and Manchada Paramuna) are more adapted to the tropical conditions and that this adaptation is reflected in better fertility rates. Several works compiled by Fernández & Useche (1981) showed a mean fertility rate of 61 % in Blackface ewes and 85 % in Criolla ewes. The Blackface breed was developed in Scotland at 200 to 800 m a.s.l. and is well adapted to adverse environments. Blackface and Criolla breeds were the base for developing the Manchada Paramuna breed (Scott *et al.* 1990).

Skea & Pastrana (1980) reported that the body weight of Criolla ewes at their adult age is about 33 kg, whereas crossbred Blackface x Criolla ewes reach 45 kg. The lesser body weight of Criolla ewes is probably related to the natural selection process when there is a decrease in body weight to reduce nutritional requirements with limited feed (Hulet, 1979; Moreno Meneses *et al.* 2013).

Pérez & Pulido (1989) reported a mean body weight at birth of 3.2 kg in Criolla lambs. The mean body weight at weaning in Criolla lambs of the present work was higher than that reported by those authors. Probably the lesser body weight at birth influenced the mortality rate of lambs at weaning, which was higher in Criolla than in Blackface and Manchada Paramuna (Table 2). Pérez & Pulido (1989) reported a mean the mortality rate at weaning of 20 % in Criolla lambs and 7.2 % in Manchada Paramuna lambs.

The results obtained in the present study showed that Colombian crossbred ewes had longer cycles (17.8 days) than European breeds, which are 16.7 days' length (Hulet & Shelton, 1980) and are similar to other native breeds, such as Pelibuey in México (Aké-Villanueva *et al.* 2019). Other studies in Colombia show that the average duration of estrous cycles was 17,3 days in pure Romney Marsh ewes (Obando Correa *et al.* 1988) and 16.8 days in Criolla x Romney Marsh crossbred ewes (Gaviria & Hernández, 1994). The estrous cycle length in ewes seems to be affected by breed (Quirke *et al.* 1985). Different lengths of estrous cycles in ewes were reported by (Coelho *et al.* 2006) in the template zone and attributed to the effect of photoperiod on the hormonal control of reproductive seasonality. Currently, the endocrine values for progesterone around the estrous are used in ewes to synchronize the estrus cycle (Maksimović *et al.* 2017).

The progesterone values of Colombian crossbred ewes were obtained in the present study with a mean of 11.52 nmol/L. The literature reports lower values in different breeds and latitudes, for example, Bass *et al.* (2017) reported serum progesterone at estrus of European ewes under different planes of nutrition, between 0.2 and 0.87 nmol/L, which agree with the values obtained in the present experiment (0.19 to 0.51 nmol/L). Arroyo-Ledezma *et al.* (2013) reported maximum values of progesterone on days 9 and 10 of the estrous cycle in Mexican ewes of 5.12 nmol/L.

Gaviria & Hernández (1994) informed maximum mean values of progesterone on day 12 of the estrous cycle in crossbred ewes in Colombia of 15 nmol/L, which are higher than the observed values in this study on day 14 (mean 10.9 nmol/L). Progesterone levels normally drop on day 14 of the ovine estrous cycle (Bass *et al.* 2017), which agrees with the present work. Balara *et al.* (2015) reported progesterone profiles of Santa Ines ewes in winter and summer under the tropical conditions of the state of Rio de Janeiro (Brazil) They found that about 50 % of the ewes had mean progesterone concentrations under 3.2 nmol/L, confirming the low reproductive seasonality in Santa Ines ewes.

These types of studies on native sheep are necessary for knowing reproductive physiology and for establishing development programs for conservation, use, and promotion with rural farmers as economic and production alternatives (Shrestha, 2005).

The information on hormonal determinations showed that the duration of the estrous cycle and the progesterone profile in Criolla x Romney crossbred ewes in Colombian tropical highlands have similar patterns to those observed in other ovine breeds of different latitudes.

The progesterone levels in the native breed presented little variation related to breeds European for the day of peak and time duration of secretion (luteal phase).

Since sheep breeding is increasing in Colombia, its production and profitability depend on the knowledge and management of the physiology of reproduction, therefore this area of knowledge requires further research in tropical highlands conditions.

Conflicts of interest: The manuscript was prepared and revised by all authors, who declare the absence of any conflict which can put the validity of the presented results at risk.

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