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EVALUATION OF THE PRODUCTIVE PERFORMANCE OF COLOMBIAN HAIR SHEEP BASED ON GROWTH TRAITS

EVALUACIÓN DEL DESEMPEÑO PRODUCTIVO EN OVINOS DE PELO COLOMBIANO A TRAVÉS DE CARACTERES DE CRECIMIENTO

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ABSTRACT

Contextualization: Colombian hair sheep [CHS] are animals of great importance, because they are genetic resource that has more than 500 years of adaptation to the environment; besides, these animals have a transcendental role in Colombia for their contribution to food security and family economy. However, a great part of the sheep production in the country presents low production parameters.

Knowledge gap: ignorance of Colombian hair sheep [CHS] biotypes' productivity has led to the undervaluation of the genetic resource found in these animals, accompanied by insufficient efforts to improve sheep production systems.

Purpose of the study: determine the productive performance of three biotypes of Colombian hair sheep.

Methodology: this study was conducted in these biotypes of hair sheep: Ethiopian [CHS_E] (40 individuals), Sudan [CHS_S] (60) and Creole crossed with Pelibuey [CHS_P] (60). Five growth traits [birth weight, adjusted weaning weight at 90 days, adjusted final weight at the age of 1 year, and pre-weaning and post-weaning weight gain] were evaluated. Descriptive statistical and variance analysis were performed based on fixed effect such as sex, farm, type of birth, parent, and season of birth. Also, a Duncan's multiple range test was performed.

Results and conclusions: CHS_E showed low productive parameters that were mostly affected by the variables sex and farm [$p \leq 0.05$]. CHS_s displayed a low to moderate productive performance and many traits were also affected by sex and farm [$p \leq 0.05$]. Lastly, CHS_P showed moderate to high productive parameters, which were mainly affected by parent, season, and type of birth [$p \leq 0.05$]. The results determined the productive performance of the three sheep biotypes, among which CHS_E showed low growth parameters, CHS_S showed low to moderate parameters, and CHS_P displayed moderate to high parameters. In all cases, the three biotypes were mostly affected by non-genetic variables.

Keywords: genetic resource, live weight, *Ovis aries*, weight gain.

RESUMEN

Contextualización: los ovinos de pelo colombianos son animales de gran importancia porque representan un recurso genético que contiene más de 500 años de adaptación al medio ambiente; además, juegan un papel trascendental ya que contribuyen a la seguridad alimentaria y a la economía familiar de Colombia. Sin embargo, una gran parte de la producción ovina del país presenta parámetros productivos bajos.

Vacío de conocimiento: el desconocimiento de la productividad de los biotipos de ovinos de pelo colombiano [OPC] ha causado que se subvalore el recurso genético de los ovinos que se encuentran en el país, acompañado de los insuficientes esfuerzos para mejorar los sistemas productivos ovinos.

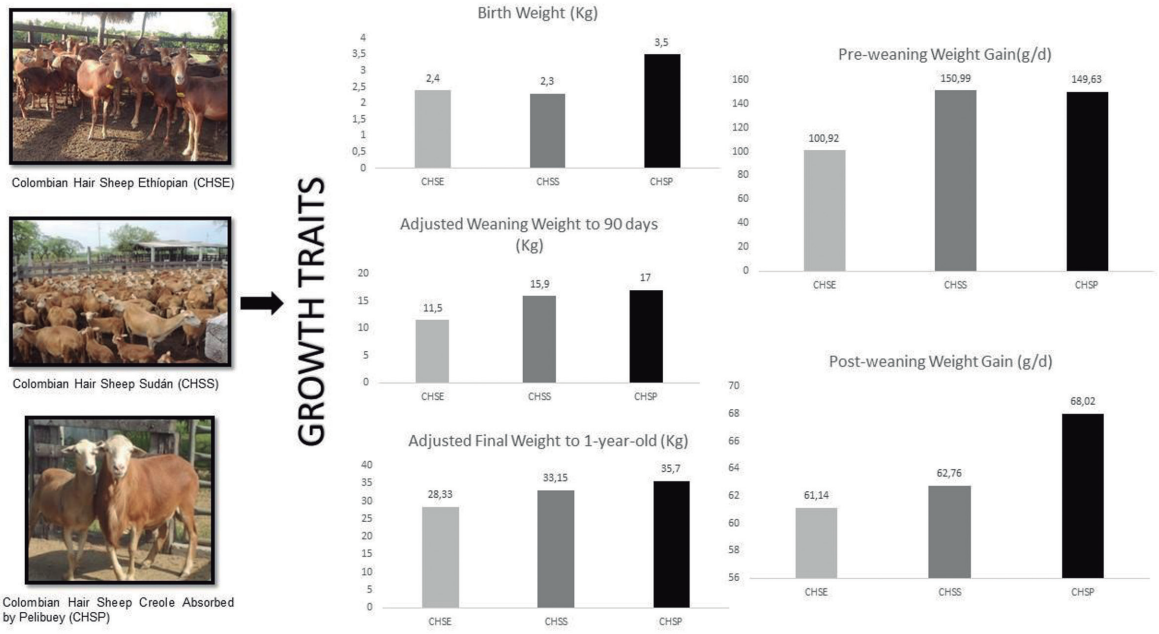
Propósito del estudio: el objetivo de este estudio fue determinar el desempeño productivo de tres biotipos de ovinos de pelo colombiano.

Metodología: este estudio fue llevado a cabo con los siguientes biotipos de ovinos: Etiope [OPC_E] (40 individuos), Sudán [OPC_S] (60) y criollos cruzados con Pelibuey [OPC_P] (60). Se evaluaron cinco características de crecimiento [peso al nacimiento, peso ajustado a los 90 días, peso final ajustado al año y ganancia de peso predestete y ganancia de peso postdestete. Se realizó un análisis estadístico de carácter descriptivo y un análisis de varianza, en el que se consideraron los efectos fijos de sexo, finca, tipo de parto, padre y época de nacimiento. Además, se realizó la prueba de rango múltiple de Duncan.

Resultados y conclusiones: los OPC_E presentaron parámetros productivos bajos; los caracteres evaluados estuvieron, en su mayoría, influenciados por los efectos sexo y finca [$p \leq 0.05$]. Los OPC_S, mostraron un desempeño productivo entre bajo y medio; el sexo y la finca afectaron [$p \leq 0.05$] la mayoría de las variables de respuesta. Los OPC_P, obtuvieron parámetros productivos entre medios y altos; estuvieron influenciados principalmente por el padre, tipo de parto y época de nacimiento [$p \leq 0.05$] en la mayoría de los caracteres. Los resultados determinaron el desempeño productivo para los tres biotipos de esta forma: los OPC_E presentaron parámetros de crecimiento bajos; los OPC_S, entre bajo y medio; los OPC_P, entre medios y altos. En todos los casos, los tres biotipos estuvieron influenciados por efectos no genéticos en su mayoría.

Palabras clave: recurso genético, peso vivo, *Ovis aries*, ganancia de peso.

GRAPHIC SUMMARY



Source: authors

1. INTRODUCTION

Sheep are found worldwide due to their adaptation to different climatic conditions. Besides, these animals are used for meat, wool, milk, and manure production; therefore, they serve as a multi-purpose species (Knapik et al., 2017). The production of CHS, in Colombia, is distributed mainly in the Caribbean region and is performed under extensive and transhumance farming systems with a low technological level. These production systems belong mostly to farmers and indigenous groups. The diet of sheep depends on the availability of forage, and breeding is done using reproducers of the same biotypes in the region. Sheep are also produced under mixed farming systems, in which production occurs alongside cattle or agricultural activities with a more developed technological level (Corpoica, 2007).

CHS produce meat in environments where other species are not able to. Besides, these animals display advantages such as high fertility and prolificacy, disease resistance, and a docile character. Also, sheep feed on harvest products and subproducts (Arcos et al., 2002), being able to transform low nutritional quality food into protein [meat] (Simanca et al., 2016). Sheep also have an important role in food security and in the economy of small-scale producers (Acero-Plazas, 2014). However, there is in-

sufficient research about these animals, as well as scarce genetic improvement programs to optimize the productive parameters (Simanca et al., 2016).

In Colombian sheep farming, production parameters and productivity are low due to marginality in these production systems (Arcos et al., 2002), the climatic conditions that affect forage quality and availability -particularly in the dry season- (Maza et al., 2015), high levels of inbreeding, and sanitary problems (Arcos et al., 2002). Furthermore, the lack of information about growth traits creates the need to define parameters that allow to evaluate the behavior of CHS under tropical conditions.

It is also important to establish genetic improvement programs to enhance the productive and reproductive parameters of sheep (Vergara et al., 2017). However, recent developments in sheep production and agroindustry have prompted the introduction of foreign breeds, the use of equipment and technology, technical training, among others, to satisfy the demand for sheep products (Asoovinos, 2010). The expectations for this sector have increased because of the technification of sheep production chain and commercialization (Simanca et al., 2016). Accordingly, this study aimed to determine the productive performance of three biotypes of CHS.

2. MATERIALS AND METHODS

Animals. 160 Creole hair sheep [122 males and 38 females] of the Ethiopian [CHS_E], Sudan [CHS_S] and Creole crossed with Pelibuey [CHS_P] biotypes were studied in the departments of Cesar, Córdoba, and Valle del Cauca in Colombia.

Measurements of live animals. A total of 160 individuals were used in this study. The sheep were identified based on the tattoo on their ear or tail. The measurements of birth weight [BW] during the first 24 hours, adjusted weaning weight to 90 days [AWW], adjusted final weight to 1 year [AFW], pre-weaning weight gain [WGPRE], and post-weaning weight gain [WGPOS] were recorded.

From the first biotype, 40 CHS_E individuals [21 males and 19 females] born in wet [May – November] or dry seasons [December - April] were assessed. The animals belonged to five farms, including four from the department of Córdoba [located in the municipalities of Chimá, Los Córdobas, San Andrés de Sotavento and San Pelayo] and one farm from the department of Cesar [settled in Valledupar] [Table 1]. The individuals were maintained under an extensive production system with Angleton [*Dichantium aristatum*], Brachiarias [*Brachiaria* sp.], Colosuana [*Bothriochloa pertusa*], and Guinea [*Megathyrsus maximus*] pastures.

Table 1. Location and climatic description of the municipalities.

Municipality	Location	Altitude m a. s. l.	Temperature °C	Classification of Holdridge
Chimá	9º 11' North latitude and 75º 33' West longitude	7	28	Tropical dry forest
Chimichagua	9º 15' North latitude and 73º 48' West longitude	49	30-40	Tropical dry forest
Ciénaga de Oro	8° 52' North latitude and 76° 32' West longitude	13	27	Tropical dry forest
El Cerrito	3º 27' North latitude and 73º 48' West longitude	1000	24	Tropical dry forest
Los Córdobas	8° 54' North latitude and 76° 21' West longitude	40	31	Tropical dry forest
San Andrés de Sotavento	9° 08' North latitude and 57° 30' West longitude	100	28	Tropical dry forest
San Pelayo	8° 58' North latitude and 75° 51' West longitude	8-235	28	Tropical dry forest
Valledupar	10° 29' North latitude and 73° 15' West longitude	168	28.4	Tropical very dry forest

Source: Holdridge [2000]

From the second biotype, 60 CHS_S animals [41 males and 19 females] born in the wet [May – November] or dry seasons [December - April] were evaluated. The animals belonged to six farms, five from the department of Cesar [four located in Valledupar and one in Chimichagua] and one farm from Córdoba, located in Ciénaga de Oro [Table 1]. The diet of the animals was mainly based on Colosuana [*Bothriochloa pertusa*], Angleton [*Dichantium aristatum*], and Guinea [*Megathyrsus maximus*] pastures.

Finally, From the third biotype [CHS_P], 60 males born in wet or dry seasons were studied. The clime in the area was bimodal with four seasons [wet 1: March - May; wet 2: October - November; dry 1: December - February; dry 2: June – September]. The animals belonged to a farm located in El Cerrito, a department of Valle del Cauca [Table 1]. The production system was associated with sugarcane crops [*Saccharum officinarum*], due to the high selective capacity of sheep that contributes to weed control in the border areas and within the sugarcane crop area from the third

month of age. The animals at this farm are selectively bred; therefore, a family structure of 60 offspring from 6 parents [10 from each parent] was available.

The sheep of the three biotypes were bred through natural mating and all the routine sanitary management protocols were fulfilled, including deworming, vitamination, and vaccination; vaccination is done based on the disease prevalence in each region. According to the Holdridge life zone system, all the municipalities correspond to a Tropical Dry Forest zone, except for Valledupar, which is classified as a Tropical Very Dry Forest zone. Table 1 provides a climatic description of the municipalities included in this study.

Statistical analyses. A descriptive analysis of all the study traits was performed: birth weight [BW] during the first 24 hours, adjusted weaning weight to 90 days [AWW], adjusted final weight to 1-year-old [AFW], pre-weaning weight gain [WGPRE], and post-weaning weight gain [WGPOS]. The data were analyzed by GLM least squares with age as a covariable, using S. A. S 9.4 statistical package Statistical Analysis System Institute (SAS, 2013). Two fixed models, since the non-genetic effects did not vary among biotypes, were used.

The effects considered were sex, farm, type of birth, parent, and birth season. The first model [Equation 1] was used to analyze CHS_E and CHS_S, which included the following non-genetic effects: sex [male-female], farm [1B, 1C, 1G, 1I, 1U, 2A, 2C, 2P, 2SJ, 2VC, and 2VL], and season of birth [dry and wet]. The second fixed model [Equation 2] was used for CHS_P and included the following non-genetic effects: parent [1, 2, 3, 4, 5, and 6], type of birth [single or multiple], and season of birth [dry 1, dry 2, wet 1, and wet 2]. The variable parent was considered a fixed effect given the low number of offspring per parent.

Model for CHS_E and CHS_S

$$Y_{ijkl} = \mu + S_i + F_j + EN_k + \varepsilon_{ijkl}$$
$$Y_{ijkl} = \mu + S_i + F_j + EN_k + \varepsilon_{ijkl}$$

(Equation 1)

Yijkl = BW, AWW, AFW, WGPRE, WGPOS

μ = general mean

Si = fixed effect of the i-th sex

Fj = fixed effect of the j-th farm

ENk = fixed effect of the k-th season of birth

εijkl = random error

Model for CHS_P

$$Y_{ijkl} = \mu + P_i + TP_j + EN_k + \varepsilon_{ijkl}$$

(Equation 2)

Yijkl = BW, AWW, AFW, WGPRE, WGPOS

μ = general mean

Pi = fixed effect of the i-th parent

TPj = fixed effect of the j-th type of birth

ENk = fixed effect of the j-th season of birth

εijkl = random error

A Duncan's multiple range test was performed to detect significant differences among means using S.A.S. 9.4 (2013).

3. RESULTS AND DISCUSSION

Ethiopian Colombian hair sheep. Table 2 shows the least squares means of the growth traits [BW, AWW, AFW, WGPRE, and WGPOS] for CHS_E, as well as the results of the mean difference test for the variables sex [S], farm [F], and season of birth [SB].

Table 2. Comparison of the mean values of the growth traits of CHSE in response to sex, farm, and season of birth.

Factor	n	BW (Kg)	AWW (Kg)	AFW (Kg)	WGPRE (g/d)	WGPOS (g/d)
General mean	40	2.4±0.6	11.5±3.3	28.3±6.2	100.9±36.9	61.1±18.2
Sex						
Female	19	2.5±0.6^{a}	11.5±3.1^{a}	24.5±4.9^{b}	100.9±33.9^{a}	51.6±16.2^{b}
Male	21	2.4±0.6^{a}	11.5±3.5^{a}	30.0±5.4^{a}	101.0±40.4^{a}	72.3±16.5^{a}
Farm						
1B	10	2.7±0.5^{a}	10.3±2.5^{b}	27.3±4.0^{b}	85.1±25.7^{b}	69.0±19.1^{ab}
1C	6	2.7±0.4^{a}	15.1±3.1^{a}	32.8±2.4^{a}	137.7±33.1^{a}	76.4±9.0^{a}
1G	10	2.9±0.5^{a}	9.6±1.3^{b}	25.5±3.8^{bc}	74.7±17.2^{b}	58.5±13.5^{b}
1I	10	1.8±0.3^{b}	11.0±2.5^{b}	22.7±3.8^{c}	101.8±26.1^{b}	45.8±18.1^{c}
2C	4	1.9±0.1^{b}	15.3±4.1^{a}	35.8±7.5^{a}	148.8±46.0^{a}	79.6±14.0^{a}
Season of Birth						
Wet	19	2.6±0.6^{a}	11.4±2.9^{a}	26.5±5.5^{a}	98.4±33.8^{a}	56.3±18.1^{b}
Dry	21	2.3±0.6^{b}	11.6±3.6^{a}	28.2±6.1^{a}	103.2±41.0^{a}	68.5±19.0^{a}

n = number of observations; values with a different superindex (a, b, c) in the same column indicate a difference of means**. Source:** authors

The CHS_E shows BW, AFW, WGPRE and WGPOS values above those reported by Ucros (2001) for Ethiopian biotype in the Savanna of Sucre, while AWW and AFW was lower than the value found by the same author; although Ucros (2001) did not specify the age of the sheep when AWW and AF were measured, which could have been older than the animals in our research and

therefore results were better. However, Montes-Vergara et al. (2022) found higher values in CHS for BW, AWW and WGPRE compared to those reported in the present study, which may have been due to better sheep management conditions on the farm. Further, Noriega-Márquez et al. (2022) obtained higher BW values in the treatment of CHS lambs with continuous suckling and in CHS with restricted suckling; and lower for AWW and WGPRE. However, they were weaned at 90 days, that is a younger age than the age of this study.

BW was affected by F, the individuals from farm systems 1B, 1C, and 1G showed the highest weights. This can be largely explained by the nutritional [forage abundance], genetic [phenotype-based selection of individuals], and reproductive [directed mating with select males] managements of these productive systems. It was also observed that BW was affected by SB, and the highest weight values were found in the wet season; this behavior is similar to the one found by Montes-Vergara et al. (2022). Differences were found in AWW and WGPRE among farms, given that 1C and 2C showed greater values.

AFW was affected by S and F, since males showed greater weights than females and individuals from farms 1C and 2C had the highest values, males weighed 5.5 Kg more than females. WGPOS was affected by S, F, and BS; for example, males showed 28.64% more weight gain than females and the highest values were found for individuals from farms 1C and 2C, as well as those born in the dry season. This relates to the fewer growth rate and smaller size of females compared to males (Dzib et al., 2011). Further, the production of testosterone and dihydrotestosterone -two potent anabolic agents- increases linear growth, weight gain, and muscle mass; therefore, males display greater body mass gain and weight than females (Álvarez et al., 2009).

Sudan Colombian hair sheep. Table 3 shows the least squares means of the growth traits [BW, AWW, AFW, WGPRE, and WGPOS] for CHS_S, as well as the results of the mean difference test for the variables sex [S], farm [F], and season of birth [SB].

Tabla 3. Comparison of the mean values of the growth traits of CHSs in response to sex, farm, and season of birth

Factor	n	BW (Kg)	AWW (Kg)	AFW (Kg)	WGPRE (g/d)	WGPOS (g/d)
General mean	60	2.3±0.6	15.9±3.7	33.2±6.4	151.0±40.8	62.8±19.3

Sex						
Female	19	2.2±0.8^{a}	14.4±2.7^{b}	28.8±5.4^{b}	135.9±30.7^{b}	55.0±20.0^{b}
Male	41	2.4±0.5^{a}	16.6±3.9^{a}	32.9±6.2^{a}	158.0±43.3^{a}	70.5±20.1^{a}
Farm						
2P	8	2.1±0.8^{b}	15.7±4.1^{ab}	29.2±6.2^{bc}	151.4±46.4^{ab}	69.1±14.0^{bc}
2A	9	2.6±0.5^{a}	18.4±3.8^{a}	32.1±4.4^{b}	174.6±38.1^{a}	72.0±20.0^{b}
2SJ	12	2.2±0.2^{b}	17.7±2.8^{ab}	39.6±5.1^{a}	171.9±30.8^{a}	87.0±10.6^{a}
1U	7	1.4±0.2^{c}	15.4±2.6^{ab}	27.5±6.5^{c}	155.2±27.7^{ab}	35.8±7.7^{d}
2VC	10	2.7±0.4^{a}	14.3±4.8^{b}	28.2±4.0^{bc}	129.1±51.5^{b}	54.8±13.9^{c}
2VL	14	2.5±0.5^{ab}	14.3±2.7^{b}	30.1±2.3^{bc}	131.6±30.4^{b}	63.5±19.2^{bc}
Season of Birth						
Wet	15	2.5±0.7^{a}	15.8±3.9^{a}	30.4±5.8^{a}	147.7±40.0^{a}	75.2±18.8^{a}
Dry	45	2.2±0.5^{b}	15.9±3.7^{a}	31.9±6.4^{a}	152.1±41.5^{a}	62.3±20.9^{b}

n = number of observations; values with a different superindex (a, b, c) in the same column indicate a difference of means. **Source:** authors

The CHS_S showed high values for BW, AWW, WGPRE and WGPOS, compared to the parameters reported by Ucros (2001) for Sudan biotype, while Noriega-Márquez et al. (2022) were only above for BW both in the treatment of CHS lambs with continuous suckling and CHS with a restricted one; this may have been due to the handling of the animals, and the use of only male lambs and from single births. Montes-Vergara et al., (2022) in CHS obtained a higher value of BW and lower of AWW, and a WGPRE equal to that found in CHS_S. On the other hand, Maza et al. (2015) measured WGPOS in the Sudan biotype in response to two treatments, supplemented and non-supplemented, reporting greater weight gain [64.68 ± 8.1 g/d] compared to this study, under the first treatment, and fewer weight gain [29.36 ± 9.4 g/d] under the second treatment. Most of the farms involved in this study do not use supplementation, which explains a lower WGPOS than the one reported by Maza et al. (2015).

BW was affected by F and BS, since the highest values were found for the individuals from systems 2A and 2VC and those born in the dry season. Montes-Vergara et al. (2022) also obtained the highest BW in the dry season. AWW, AFW, WGPRE, and WGPOS were affected by S and F; besides, WGPOS was also affected by SB. For all traits, males showed higher weights than females; it was found that F affected all the parameters measured. Farms 2A and 2SJ showed the highest weights and weight gain since the animals from these farms

consumed carob [*Ceratonia siliqua*] and mesquite [*Prosopis juliflora*] fruits in harvest season. Besides, in both farms, there is supervised mating and reproduction after a selection process.

Several variables showed a greater weight gain in males individuals: for AWW, males displayed 2.2 Kg more than females; for AFW, this difference was 4.1 Kg; for WGPRE, 22.1 g/d; and for WGPOS, 15.5 g/d. Montes et al (2018) reported the same effect of sex on AWW for CHS, while Arcos et al. (2002) found the same tendency for the other parameters. Moreover, Lupi et al. (2015) mention that the effect of S increases with age, and Macedo y Arredondo (2008) state that there is a predisposition associated with the physiological functions of both sexes, mostly due to hormonal effects that increase with age; also, it was found that SB affected BW and WGPOS. Accordingly, the wet season showed the highest BW and WGPOS values, exceeding the dry season by 300 g for BW and 12.9 g/d for weight gain; this could be attributed to a greater availability of forage in the wet season, which benefits pregnant ewes by promoting daily weight gain.

Colombian Creole hair sheep crossed with Pelibuey. Table 4 shows the least squares means of the growth traits [BW, AWW, AFW, WGPRE, and WGPOS] for CHS_P, as well as the results of the mean difference test for the variables parent [P], type of birth [TB] and season of birth [SB].

Tabla 4. Comparison of the mean values of the growth traits of CHSP in response to parent, type of birth, and season of birth.

Factor	n	BW (Kg)	AWW (Kg)	AFW (Kg)	WGPRE (g/d)	WGPOS (g/d)
General mean	60	3.5±0.7	17.0±3.1	35.7±3.3	149.6±33.3	68.0±11.6
Parent						
1	10	3.6±0.7^{a}	15.7±3.1^{b}	33.5±2.5^{c}	134.1±28.5^{b}	60.0±7.3^{bc}
2	10	3.4±0.6^{a}	18.1±3.4^{a}	34.6±2.7^{c}	162.7±33.4^{a}	56.9±9.4^{c}
3	10	3.3±0.6^{a}	19.0±2.2^{a}	41.7±2.6^{a}	174.8±22.3^{a}	70.6±9.9^{a}
4	10	3.3±0.6^{a}	18.1±3.1^{a}	37.7±2.5^{b}	164.4±32.3^{a}	69.3±11.5^{a}
5	10	3.7±0.5^{a}	15.3±3.0^{b}	37.0±3.5^{b}	128.6±30.1^{b}	66.5±10.0^{ab}
6	10	3.8±0.9^{a}	15.8±2.2^{b}	40.6±2.8^{a}	133.2±26.0^{b}	74.1±8.6^{a}
Type of birth						
S	21	3.9±0.6^{a}	18.9±2.8^{a}	37.1±3.5^{a}	167.6±29.9^{a}	59.9±9.8^{b}
M	39	3.4±0.7^{b}	16.0±2.7^{b}	37.7±4.3^{a}	139.2±31.2^{b}	69.6±9.0^{a}

Season of birth						
Wet 1	5	4.0±0.5^{a}	17.3±4.0^{a}	39.3±3.7^{a}	147.7±44.2^{a}	69.1±9.0^{a}
Dry 1	15	3.7±0.8^{ba}	15.0±1.7^{b}	38.6±3.6^{ab}	125.3±18.2^{b}	70.7±10.4^{a}
Wet 2	13	3.5±0.8^{ba}	17.3±2.8^{a}	36.9±5.7^{c}	153.9±28.1^{a}	64.9±9.9^{a}
Dry 2	27	3.4±0.6^{b}	17.9±3.3^{a}	36.8±3.1^{c}	161.5±34.2^{a}	63.8±11.6^{a}

n = number of observations; values with a different superindex (a, b, c) in the same column indicate a difference of means. **Source:** authors

BW, AWW and WGPRE values were above those reported in Pelibuey sheep by Hinojosa-Cuellar et al. (2012) and Quiroz et al. (2012); CHS also was higher than the value reported by Noriega-Márquez et al. (2022) and Montes-Vergara et al. (2022) for the first two variables. For Lenis-Valencia et al. (2022), who used a cross between CHS x Pelibuey, were found higher values for BW and WGPRE, and lower for AWW. On the other hand, Quiroz et al. (2012) found greater WGPOS [199.25 g/d] than the one reported here [68.0±11.6 g/d]; nevertheless, the animals studied by Quiroz et al. (2012) had optimal productive traits to be used in genetic improvement. Regarding AFW, [35.7±3.3 Kg] to an average age of 411 days, our findings were below (59.1 Kg) than those reported by Arredondo-Ruiz et al. (2012) since the authors studied animals of approximately two years of age.

BW was affected by TB and SB, finding greater weights in individuals born from single births and those from the wet 1 season. AWW and WGPRE were affected by all the variables; it was found the highest weights and weight gain in lambs from parents 2, 3 and 4, as well as in individuals from single births and from the wet 1, wet 2, and dry 2 seasons. AFW was affected by P and SB; for example, parents 3 and 6 showed offspring with the highest weights, and the wet 1 season also showed the greatest weights. Meanwhile, WGPOS was affected by P and TB, finding the highest values for lambs from parents 3, 4, and 6, as well as for individuals born from multiple births. It was observed that P affected all the traits, except for BW. Parent 3 showed the best performance for four of the traits [AWW, AFW, WGPRE, and WGPOS] since the litters from this parent had the highest weights and weight gain compared to the others. TB affected BW, AWW, WGPRE, and WGPOS, a similar behavior was reported by Lenis-Valencia et al. (2022); accordingly, animals born from single births showed greater values for all growth traits, except for AFW. In the latter case, animals from multiple births showed higher values.

For BW, the difference between single and multiple births can be explained by the competition for nutrients and spa-

ce among siblings from multiple births (Macedo y Arredondo 2008). Meanwhile, for AWW and WGPRE, lamb growth rates depend mainly on the milk production of the ewe, so lambs born from multiple births will have less milk available compared to those from single births. In contrast, WGPOS showed higher values for individuals born from multiple births, in comparison to single births. This finding could be attributed to a compensatory growth of lambs born from multiple births, which, occasionally, can outgrow those from single births (Macedo y Arredondo 2008). Another reason for this behavior is that weaning could have led to an improvement in nutrition compared to suckling, since the lambs had to compete for milk intake at the latter stage. However, the animals in this study received supplementation during the suckling period, which could have helped to compensate for the milk deficit of multiple offspring and weaning might have been less critical for these offspring compared to those from single births, as shown by the WGPOS.

BS affected BW, AWW, AFW, and WGPRE. Particularly for BW and AFW, the wet 1 season showed higher values, which could be due to a greater availability of forage for pregnant ewes and adults during this season; also, the low amount of data for this season might have had a positive influence. For AWW and WGPRE, the dry 1 season showed the lowest weights and weight gain, likely due to lower food availability. A comparison of the productive performance of the three sheep biotypes showed that CHS_E has lower productive trait values than those found for CHS_P, since the former biotype is smaller in size. CHS_E is raised in extensive systems, in which forage is of low quality and genetic improvement processes are scarce; in this biotype, males outperformed females, farms 1C and 2C showed the best results for most traits, and season of birth affected BW and WGPOS.

For CHS_S, the productive traits showed higher values than those for CHS_E, yet lower values than those found for CHS_P. These results obey differences in forage availability, reproducer selection based on phenotype and history records, controlled breeding of replacement animals, and access to technical assistance. In general, males showed higher values than females for all traits, farm 2SJ showed the best results for most traits, and season of birth only affected BW. Lastly, CHS_P showed the highest productive trait values of the three biotypes, which is attributed to genetic improvement, the feeding system used, the selection of replacement individuals, and the use of productive history records and assessments. Parent 3 showed the best results for most traits. Also, animals born from single births had the highest weights until weaning, although multiple births positively affected WGPOS.

4. CONCLUSIONS

This study provides evidence of the productive performance of three Colombian hair sheep biotypes: CHS_E showed low growth parameters; CHS_S, low to moderate parameters; and CHS_P, moderate to high growth parameters. The first two biotypes were affected by the variables sex and farm, whereas CHS_P was mainly affected by parent and type of birth. Overall, our findings are highly relevant since there are few studies about the productive parameters in sheep in Colombia.

AUTHOR'S CONTRIBUTION

Yineth Alexandra Palacios-Erazo: Research, data analysis, writing, original draft and editing. Manuel Fernando Ariza-Botero: review and resource acquisition. Moris de Jesús Bustamante-Yánez: review and resource acquisition. Óscar David Vergara-Garay: data analysis, review, and resource acquisition. Luz Ángela Álvarez-Franco: project manager, supervision, review, and resource acquisition.

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Conflicto de intereses
Los autores declaran no tener ningún conflicto de intereses.