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Original

Estimation of the growth curve in Colombian hair sheep using the Richards model

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ABSTRACT

Objective. To describe growth in Colombian hair sheep (OPC) using the Richards model. **Materials and methods**. A total of 2086 records were obtained from weighing every 30 days in OPC sheep from birth to slaughter and weaning at 90 days. In addition, the sex (S), type of lambing (TP) and time of birth (Eponac) of the animals were considered. The data were analyzed with the Richards model using the NLIN procedure of SAS. **Results**. The asymptotic weight estimation indicated by parameter A for males was 7.8 kg higher than that of females; in the TP, this same parameter indicated a 22% superiority between single and multiple births; finally, in the Eponac variable, the best weight values corresponded to the rainy season with 5 kg more than the animals born in the dry season. For the K parameter, the reference values oscillate between 0.001 and 0.004 in the variables S, TP and Eponac; as well as the correlation between the A and K parameters, the values are between -0.98 and -0.99 in all the variables studied. **Conclusions**. The Richards model explained the development of the animals and allowed observing the effect of the variables S, TP and Eponac, evidencing in each of these a slow growth, but with high weights at maturity.

Keywords: Growth curves; Creole sheep; variables; parameter; time (*Source: CAB*).

RESUMEN

Objetivo. Describir el crecimiento en ovinos de Pelo Colombiano (OPC) mediante la utilización del modelo Richards. **Materiales y métodos.** Se obtuvieron 2.086 registros procedente de pesajes realizados cada 30 días en ovinos OPC desde el nacimiento hasta el sacrificio, con destete a los 90 días, adicional se tuvo en cuenta el sexo (S), tipo de parto (TP) y la época de nacimiento (Época) de los animales. Los datos fueron analizados con el modelo Richards utilizando el procedimiento NLIN del SAS. **Resultados.** La estimación del peso asintótico indicado por el parámetro *A* para los machos fue 7.8 kg superior al de las hembras; en el TP este mismo parámetro indico un 22% de superioridad entre los nacimientos simples y múltiples, por último, en la variable Eponac los pesajes de mejor valor correspondieron a la época de lluvia con 5 Kg más que los animales nacidos en época seca. Para el parámetro K los valores de referencia oscilan entre 0.001 y 0.004 en las variables S, TP y Eponac; al igual que la correlación entre los parámetros A y K los valores se encuentran

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entre -0.98 y -0.99 en todas las variables estudiadas. **Conclusiones.** El modelo Richards explico el desarrollo de los animales y permitió observar el efecto de las variables S, TP y Eponac evidenciando en cada una de estas un crecimiento lento, pero con pesos altos a la madurez.

Palabras clave: Curvas de crecimiento; ovinos criollos; variables; parámetro; época (*Fuente: CAB*).

INTRODUCTION

Currently, the production of hair sheep in Colombia (OPC) is at an important moment in the primary animal production chain, as this system in some areas of the country, such as the Caribbean region, has gone from being seen as a secondary activity to livestock farming and self-consumption, to a scenario of greater scope for the production of animal protein (1).

Despite the specialisation of the sector and the support that some entities and associations have been providing with campaigns to increase the number of sheep, the national inventory continues to grow slowly. According to the national census reported by the Colombian Agricultural Institute (ICA), there are 1,779,697 animals, located mainly in the departments of La Guajira (43.7%), Magdalena (12.1%), Cesar (10.1%), Cesar (10.2%), Cesar (10.2%), Cesar (10.2%) and Magdalena (12.1%). 1%), Cesar (10.2%), Boyaca (8.1%), Cordoba (3.8%), Santander (2.3%), Bolivar (2.1%), Cundinamarca (2.6%), Meta (2.3%) and Sucre (1.9%), with these 10 departments accounting for 88% of the total number of sheep in the country (2).

The Caribbean region has shown the greatest growth in the country's sheep population due to cultural effects, so it is necessary to carry out more research work to demonstrate with indicators the efficiency of the predominant genetic resource in the region (Colombian Hair Sheep - OPC) for growth and meat production characteristics (3). On the other hand, from the perspective and study of animal science, it is important to take into account that each of the physiological processes of animal growth involve various factors such as the change in mass or volume of a tissue or organism in a unit of time, improving the characteristics related to growth, particularly in meat production activities (4,5), which is why it was proposed as an objective of this work, to describe growth in Colombian Hair Sheep (OPC) using the Richards model.

MATERIALS AND METHODS

Location. The study was carried out on 12 farms in the Caribbean region in the departments of Sucre and Córdoba (Colombia), which are located in the northwest of Colombia, with altitudes between 44 and 117 m above sea level. The climate of the department of Sucre ranges between 25.5 and 28.7°C. The predominant type of climate in the north and centre of the department is warm-semiarid, while towards the south it is warm semi-humid and humid. In the same way, the climate of the department of Cordoba is also determined by the geographical position and its temperatures oscillate between 26 and 28°C. The departmental territory is made up of 60% of the Gran Llanura del Caribe and the remaining part of the last foothills of the Andes mountain range**.**

Data collection and animal management. A total of 2086 sheep weighing records were used, of which 632 belong to the department of Córdoba and 1454 to the department of Sucre. Births occurred between December 2019 and the first quarter of 2020, with intervals of no more than 70 days between the first and last birth. The weights of 302 animals were analysed, comprising 158 males and 144 females, weighing every 30 days from birth to slaughter (between 10 and 13 months), for this activity a digital scale Scale Sf-912 with a capacity of 300 kg was used, performing a minimum of 10 weighings for each animal and a maximum of 13; the weaning of the evaluated individuals was carried out at 90 days.

The animals were managed under conventional grazing conditions, where the calves go to pasture with the mothers (they leave in the morning and return to the pen in the afternoon) in pastures of natural grass, Bothriochloa pertusa, Brachiaria humidicola and Brachiaria brizanta, with periods of occupation between 4 and 7 days, and rest periods between 24 and 27 days according to the management recommendations of each farm. Water and mineralised salt for sheep were also available at will. All the animals in the study were managed under the sanitary protocol of each farm in which the general recommendation was to have at least gastrointestinal parasite control and preventive vaccines for Clostridium spp. and Pasteurella spp.

Variables assessed.

Statistical analysis and growth curve. The model proposed by Richards (1959) was used to determine the growth curve, using the NLIN procedure of the SAS University, 2021® statistical package for the analyses. The Akaike information criteria (AIC), the Bayesian

information criterion (BIC), the coefficient of determination (R2), the percentage of convergent curves (PCC) and the root mean square error (RMSE) were also taken into account. The model describing the growth proposed by Richards is as follows:

$Yt = A\ (1- B\mathrm{e}\ -Kt)\text{-}m+ \varepsilon$ = Richards (6).

Where: Yt represents the weight of the animal at time t; A represents the asymptotic weight of the animal when "t" tends to infinity, generally interpreted as the adult weight of the animal; B is a fit parameter when $y \neq 0$ or $t \neq 0$; K is a maturity index or measure of earliness, expressed as a percentage ratio of maximum growth to the adult weight of the animal, the higher it is, the faster the growth rate. Likewise, m represents the inflection point of the model and ε experimental error. Similarly, the variables Sex (S), female and male; Type of parturition (TP), single and double; Time of birth (EPONAC), dry and rainy were estimated.

RESULTS

The estimates of the variables S, TP and EPONAC for parameters A, B, K and M and the fitting criteria for OPC sheep with the Richards model are listed in Table 1. The asymptotic weight estimate indicated by parameter A for males was 7.8 kg higher than that of females, showing pronounced sexual dimorphism. In the K parameter that refers to the growth speed of the animals, in both sexes the value is 0.003 that indicates a slow growth, but with high weights at maturity. The correlation between parameter A and K was -0.98 in both sexes.

In the TP, a difference between single and multiple births of 22% was observed according to parameter A, whereas, single-born animals have a slower growth than multiple births as observed in parameter K of 0.001 and 0.004, respectively. The correlation between the mentioned parameters was -0.99 for the two TPs.

The animals born in the rainy season have a difference of 5 kg with respect to those born in the dry season as observed in parameter A. The precocity in OPC sheep is similar for both seasons (dry (0.003) and rainy (0.004), as well as the correlation between parameters A and K which is -0.98 and -0.99 in the dry and rainy seasons, respectively.

Figure 1 shows a sigmoidal trend as a function of age in the growth curves corresponding to the OPCs in the different variables studied (S, TP and EPONAC) in accordance with the weights estimated by the Richards model. After approximately 60 days, a marked tendency of superiority is observed in the males with respect to the females, being more evident at the end of 350 days, while in the TP it is appreciable from 200 days and in the EPONAC it is not possible to distinguish a separation between the two curves.

Table 1. Parameter estimates (A, B, K and M) of the Richards model and the fit criteria for the variables studied.

Variable		Parameter estimation				Adjustment criteria				
		A	B	K	M	R^2_{aj}(%)	BIC	AIC	RMSE	PCC
Sex	Female	36.88	0.96	0.003	0.79	0.83	4812.3	4807.5	3.48	100
	Male	44.72	0.97	0.003	0.80	0.84	6650.7	6645.6	3.97	100
TP	Simply	56.97	0.99	0.001	0.64	0.79	4935.9	4931.2	4.52	100
	Multiple	38.72	0.95	0.004	0.88	0.86	6610.4	6605.3	3.42	100
Period	Dry	42.53	0.97	0.003	0.79	0.83	8360.7	8355.4	3.86	100
	Rain	47.54	0.98	0.002	0.69	0.81	3279.4	3275.0	4.07	100

Period: time of birth, TP: type of delivery, R2aj: adjusted coefficient of determination, BIC: Bayesian information criterion, AIC: Akaike information criterion, RMSE: Root mean square error, PCC: Percentage of convergence.

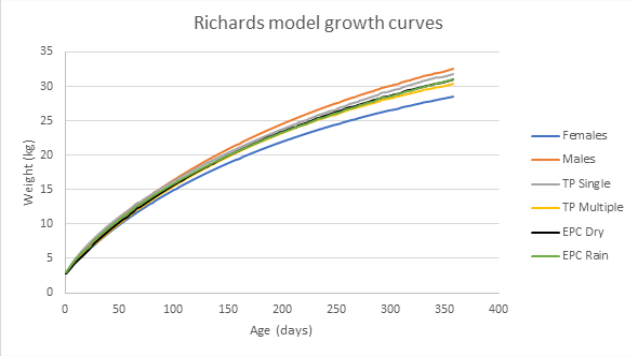

Figure 1. Growth curve of OPC sheep according to sex, type of lambing and time of birth, based on the Richards model.

DISCUSSION

Regarding the sex variable (female and male), for A values Kopuzlu et al (7) in Hemsin sheep and Hossein-Zadeh et al (8) in Shall sheep obtained higher results than those found in \sthis work for both sexes in estimates of 64.61±5.12 and 82.35±9.17; 41.51 and 48.80, respectively. However, Lenis et al (9) reported lower values in both sexes (35.13 in females and 39.59 in males) in OPC sheep; similarly, Nimase et al (10) obtained values of 25.31±0.39 and 31.75±3.22, and Balan et al (11) of 24.45±6.04 and 30.32±6.23 in Mecheri ewes, well below those obtained in OPC. The difference in weight between males and females has always been marked within mammalian animals, due to their morphometric peculiarities which are characteristics related to the release of testosterone, which acts as a growth promoter that allows the animal to have a greater weight in adulthood (7,8,11).

As for the values obtained for B, Balan et al (11) report values of 4.068±2.80 and 4.056±3.08. Likewise, Ghavi et al (12) show values of 0.98 and 0.98 and Kopuzlu et al (7) reported higher results (0.99±0.02 and 0.98±0.04). On the other hand, lower values of 0.86±0.04 and 0.96±0.03 were found in Madgyal sheep (10).

The estimated value of the parameter K shows the precocity of maturity of the lambs. In our results, no differences were found between sexes, similar to what was observed by Lenis et al (9) in OPC sheep. This result indicates that the OPC lambs studied are not very precocious and the growth rate to reach asymptotic weight is slow. Higher values were reported by Bahreini et al (13) with estimates of 0.014 and 0.013. While Tariq et al (14) present values similar to those of this study (0.004). On the other hand, Teixeira et al (15) reported lower values than those presented here (0.001) in grazing production systems. This precocity of maturity is supported at the same time by the biological correlation between A and K parameters, which was negative and high in all variables (-0.98 and -0.99), although most authors do not take it into account in the analysis, however, the same was observed by Kopuzlu et al. (7), Hossein-Zadeh et al (8) and Lenis et al (9).

For the TP variable, there were no reports of other research using the Richards model, however, according to the results obtained in this study, differences between single and multiple births can be evidenced, which may be physiologically influenced by the weight of the placenta and the number of placentomas, which increases in multiple gestation ewes, lambs from double and triple births are associated with a lower number of placentomas compared to lambs from single births (16,17). Similarly, lambs from single births show higher growth rates and higher weaning weights compared to lambs born from multiple births influenced by the higher energy intake during gestation and the volume of milk received in lactation (18,19). However, in the description of growth in Criollo sheep using the Brody model, they reported that the estimated values in animals born in single births are earlier than those born in twin births, so they can reach adult weight in less time (20).

As with the previous variable, for the time of birth, there were no reports from other studies that allow us to compare the results of the Richards model. However, we can mention that the season is influencing the growth of sheep, given that in the rainy period there is greater availability of fodder and this avoids weight loss due to the scarcity of pasture during the dry period, given that this is one of the limiting factors for ruminant production in the tropics (21,22).

In conclusion, the Richards model explained the development of the animals and allowed the effect of the variables S, TP and EPONAC to be observed, showing slow growth but high weights at maturity. The animals born in multiple births are earlier than those born in single births, therefore, they will reach their adult weight in less time.

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