Short Note [Nota Corta]

THE SCHAFFER FORMULA CAN'T PREDICT LIVEWEIGHT IN BACK BELLY SHEEP †

[LA FÓRMULA DE SCHAFFER NO PUEDE PREDECIR EL PESO VIVO DE OVINOS BLACK BELLY]

Pedro Colorado-García[1], José Luis Ponce-Covarrubias[2], Roberto Carlos Barrientos-Medina[3], Claudia Virginia Zaragoza-Vera[1], Maritza Zaragoza-Vera[1], Oswaldo Torres-Chable[1] and Alfonso Juventino Chay-Canul[1*]

[1]Universidad Juárez Autónoma de Tabasco, División Académica de Ciencias Agropecuarias, Carretera Villahermosa-Teapa, km 25, Ranchería La Huasteca 2ª Sección, Centro, Tabasco, México. C.P. 86280. Villahermosa, Tabasco, México. Email: alfonso.chay@ujat.mx
[2] Escuela Superior de Medicina Veterinaria y Zootecnia No. 3, Universidad Autónoma de Guerrero (UAGro), Técpan de Galeana, Guerrero, México.
[3]Facultad de Medicina Veterinaria y Zootecnia, Campus de Ciencias Biológicas y Agropecuarias, Universidad Autónoma de Yucatán, km 15.5 carretera Mérida-Xmatkuil, Mérida, Yucatán, México. C. P. 97135.
**Corresponding author*

SUMMARY

Background. Schaeffer's formula has been promoted as an alternative to animal weighting in recent years. However, no studies evaluating the Schaeffer formula in the Black Belly hair sheep breed have been developed. **Objective.** To evaluate Schaeffer's formula for predicting body weight in male and female Black Belly sheep reared under tropical conditions. **Methodology.** Body weight (BW, kg), thoracic circumference (TC, cm) and body length (BL, cm) were recorded in 120 Black Belly lambs (60 females and 60 males). The lambs were clinically healthy and aged between 6 and 8 months. Schaeffer's formula for calculating BW was BW (kg) = $(BL \times TC^2)/10838$. First, the distributions of the values were examined by means of a histogram showing both sets of values simultaneously. The medians of each set were then obtained and statistically compared using the Wilcoxon signed-rank test to test the null hypothesis of no difference between the two sets of measurements considered. **Results.** In the present study it was observed that Shaeffer's formula underestimated BW in Black Belly sheep ($P<0.05$) at about 5.84 kg. This weight represents about 20.40% of the observed mean BW. The underestimation was also much greater than expected in males at approximately 6.88 kg, this weight represents approximately 22.40% of the observed mean BW in males. However, for females the difference was 4.09 kg. This weight represents approximately 15.40% of the observed mean BW for females. **Implications.** Caution should be exercised in using the Schaffer formula for estimating liveweight in black belly sheep, or some adjustment to this equation should be evaluated to increase its precision and accuracy for predicting liveweight in hair sheep breeds. **Conclusion.** Under the conditions in which the present study was carried out, it was concluded that Shaeffer's formula underestimated BW in Black Belly sheep. The estimated BW differed from the observed BW ($P<0.05$), and this parameter was underestimated much more than expected in males than in females, showing that this formula is not accurate in estimating BW in male and female Black Belly sheep. As a result, estimates should be treated with caution. There is a need to develop improved prediction equations for adequate estimation of BW of male and female Black Belly sheep.

Key words: hair sheep; Live weight; Animal production; Accuracy.

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ORCID = P. Colorado-García: https://orcid.org/0009-0006-0507-8618; **J.L. Ponce-Covarrubias**: https://orcid.org/0000-0002-0182-6846; **R.C. Barrientos-Medina**: https://orcid.org/0000-0003-2144-034X; **C. Zaragoza-Vera**: https://orcid.org/0000-0002-8629-7401; **M. Zaragoza-Vera**: https://orcid.org/0000-0003-0453-8660; **O. Torres-Chable**: https://orcid.org/0000-0001-7482-6663; **A.J. Chay-Canul**: https://orcid.org/0000-0003-4412-4972

RESUMEN

Antecedentes. La fórmula de Schaeffer se ha promocionado como una alternativa al pesaje de animales en los últimos años. Sin embargo, en nuestra búsqueda hasta la fecha no se han identificado estudios que evalúen la fórmula de Schaeffer en razas ovinas de pelo. **Objetivo.** Evaluar la fórmula de Schaeffer para predecir el peso corporal en ovinos Black Belly de diferentes sexos criados en condiciones tropicales. **Metodología.** Se registraron el peso corporal (PV, kg), la circunferencia torácica (CT, cm) y la longitud corporal (LC, cm) de 120 corderos Black Belly (60 hembras y 60 machos). Los corderos estaban clínicamente sanos y tenían entre 6 y 8 meses de edad. La fórmula de Schaeffer para calcular el PV fue: PV (kg) = (LC × CT^2)/10838. En primer lugar, se examinaron las distribuciones de los valores mediante un histograma que mostraba ambos conjuntos de valores simultáneamente. A continuación, se obtuvieron las medianas de cada conjunto y se compararon estadísticamente mediante la prueba de rangos con signo de Wilcoxon para comprobar la hipótesis nula de ausencia de diferencias entre los dos conjuntos de mediciones considerados. **Resultados**. En el presente estudio se observó que la fórmula de Shaeffer subestimaba el PV de ovinos Black Belly ($P<0,05$) en unos 5.84 kg. Este peso representa aproximadamente el 20.40% del PV medio observado. La subestimación también fue mucho mayor de lo esperado en los machos con aproximadamente 6.88 kg, este peso representa aproximadamente el 22.40% del PV medio observado en los machos. Sin embargo, en las hembras la diferencia fue de 4.09 kg. Este peso representa aproximadamente el 15.40% del PV medio observado en las hembras. **Implicaciones.** Se debe tener precaución al utilizar la fórmula de Schaffer para estimar el peso vivo en ovejas Black Belly, o se debe evaluar algún ajuste de esta ecuación para aumentar su precisión y exactitud para predecir el peso vivo en razas de ovejas de pelo. **Conclusión.** En las condiciones en que se llevó a cabo el presente estudio, se llegó a la conclusión de que la fórmula de Shaeffer subestimaba el PV en la ovinos Black Belly. El PV estimado difirió del PV observado ($P<0.05$), y este parámetro se subestimaba mucho más de lo esperado en los machos que en las hembras, lo que demuestra que esta fórmula no es exacta para estimar el PV en ovinos Black Belly de diferente sexo. Por ello, las estimaciones deben tratarse con cautela. Es necesario desarrollar ecuaciones de predicción mejoradas para una estimación adecuada del PV de ovinos Black Belly de diferente sexo.

Palabras clave: ovinos de pelo; Peso vivo; Producción animal; Exactitud.

INTRODUCCIÓN

Hair sheep breeds are the main genotypes used in tropical sheep production systems (Magaña-Monforte *et al*., 2013). In these systems, the continuous determination of animal growth is a major challenge for smallholder farmers due to various factors that have been previously reported (Málková *et al*., 2021; Salazar-Cuytun *et al*., 2021). Some authors have also noted that growth and development are economically important traits and that they are usually measured using weights. It has also been reported that these parameters can be estimated using body measurements (BMs) (Tirink, 2022; Vazquez-Martinez *et al*., 2023). The MBs allow quantifying the conformation of the animal, so that it is possible to know the productive capacity of a breed or its tendency to a certain zootechnical production, sexual dimorphism and morphometric comparison with other breeds (Costa *et al*., 2020). It has also been reported that the body conformation of animals is influenced by factors such as the breed, the sex, the physiological state and the level of feeding (Arredondo-Ruiz *et al*., 2013). Also, it has been reported that some BMs, which are quick, simple, and accurate, have the potential to assess body weight (BW) in different species (Málková *et al*., 2021; Salazar-Cuytun *et al*., 2021). Determining BW from BMs is an important tool for managing sheep production systems. It can be used to monitor the growth and performance and can be an aid to producers in decisions about sheep production. It can also help producers decide how to support and manage the animals. The accuracy of BW estimates is important for the assessment of overall animal health, productivity, nutrition, and management (Vazquez-Martinez *et al*., 2023).

On the other hand, in recent years the Schaeffer's formula has been promoted as an alternative for livestock weighting. This formula has also been used in small ruminants (sheep and goats) with good results, but evaluation of this formula in hair sheep, such as the Black Belly breed, is limited (Vaidya *et al*., 2018). However, it This formula includes some BMs such as TC and BL. Schaeffer's formula is one of the most widely used techniques for predicting body weight, especially for large animals such as cattle (Johnson, 1939; Wangchuk *et al*., 2018; Jagdale *et al*., 2018; Karna *et al*., 2022). However, the reliability and concordance of this formula for predicting body weight in different livestock species under different management scenarios has not been evaluated in many studies. For the time being, we have not identified any studies that have evaluated the Schaeffer formula in hair sheep. We hypothesised that the Schaeffer formula could be used to predict BW in Black Belly sheep. The aim of this study was to evaluate Schaeffer's formula for predicting BW in male and female Black Belly sheep reared under tropical conditions.

MATERIALS AND METHODS

The animals were treated in accordance with the standards for ethical animal research of the Scientific Division of Agricultural Sciences of the Autonomous University of Tabasco (CIEI: Folio 1173-2022). The experiment was conducted at the Centro de Integración Ovina del Sureste (CIOS, 17°78' N, 92°96' W; 10 masl). It is in the Rancheria Alvarado Santa Irene 2da Seccion, municipality of Centro, Tabasco, Mexico. The unit has a humid tropical climate. Temperatures range from 15 to 44°C, averaging 26°C. Body weight (BW), thoracic circumference (TC) and body length (BL) were recorded in 120 Black Belly lambs (60 females and 60 males). The lambs were clinically healthy and aged between 6 and 8 months. Animals were weighed at 8:00 am without fasting and before the start of the feed. BW was recorded using a 300 kg capacity, 20 g accuracy fixed platform balance. The BL was measured as the distance between the dorsal point of the scapulae and the ventral point of the tuber coxae, and the thoracic girth (TG) was measured as the smallest circumference immediately posterior to the front legs in the vertical plane using a flexible glass fibre tape measure (Truper®) as described by Salazar-Cuytun *et al*. (2022).

The original formula for determining the weight of cattle, using MB in inches and BW in pounds (Johnson, 1939). However, the formula has been reformatted to use MBs in cm and BW in kg (Karna *et al*., (2022).

Schaeffer's formula for calculating BW was:

$$BW\ (kg) = (BL \times TC^2)/10838$$

where BW is body weight in kg, BL is body length in cm and TC is thoracic circumference in cm according to Karna *et al*. (2022).

To compare the adequacy of Schaeffer's estimated weights with live weights, it was considered that both measures were obtained from the same experimental units (lambs). Firstly, the degree of association between the observed weights (BW) and the estimated weights (Schaeffer's formula) of the sheep was studied through a modified scatterplot, to include both a concentration ellipse of the data and a star trace, which allows to indicate the distance of each data from the average and Pearson's correlation index, considering the sex of the animals. Secondly, the distributions of the values were examined simultaneously by using a bihistogram, to visualize a possible effect of data condition (observed, estimated) by sex in terms of location or variation. The medians of each sex comparison were then obtained and statistically compared using the Wilcoxon signed-rank test to test the null hypothesis of no difference between the two sets of measurements considered, because there was evidence against the assumptions of parametric alternative (normality, homoscedasticity). All calculations and graphs were performed in the R programming environment (R Core Team, 2023), version 4.3.1.

RESULTS

The mean (± SD), minimum and maximum weights of the animals are shown in Table 1. The BW varied from 19.55 kg to 36.45 kg. In addition, TC and BL varied from 60 to 81 cm and 40 to 60 cm respectively. Examination of the BW and the estimates obtained using Schaeffer's formula reveals an interesting pattern (Figure 1). Although in general the relationship looks similar, there is less variability (indicated by a narrower ellipse) and a higher correlation between measurements in females than in males. Consequently, Schaeffer's formula had a higher precision for predicting BW in female Black Belly sheep (r^2=0.88) than in males (r^2=0.79, Figure 1).

On the other hand, the bihistogram for the females shows the discrepancy between the BW and the estimates obtained with Schaeffer's formula (Figure 2). The median of the estimates was 4.09 kg lower than the observed BW, as confirmed by the Wilcoxon test. In the case of males, the bihistogram shows the same pattern of discrepancy, but the distance between the observed and estimated median is higher, 6.88 kg (Figure 3). Finally, we applied the same analysis procedure to the whole sample (n= 120 lambs). The bihistogram shows the same pattern of discrepancy as described for females and males (Figure 4). The difference between the estimated median and the observed) is 5.84 kg and the Wilcoxon test gives highly significant.

Table 1. Minimum and maximum values of body weight (BW) and body measurements in Black Belly sheep males and females reared under tropical conditions.

Variable	Description	Mean	SD	Minimum	Maximum
Females					
BW	Body weight (kg)	26.64	3.96	19.55	36.45
TC	Thoracic circumference (cm)	69.27	4.25	60.00	77.00
BL	Body length (cm)	49.75	3.01	44.00	57.00
Males					
BW	Body weight (kg)	30.71	3.17	23.20	37.00
TC	Thoracic circumference (cm)	73.62	4.61	63.00	81.00
BL	Body length (cm)	49.08	3.70	40.00	56.00
All					
BW	Body weight (kg)	28.68	4.11	19.55	37.00
TC	Thoracic circumference (cm)	71.44	4.79	60.00	81.00
BL	Body length (cm)	49.42	3.37	40.00	60.00

SD: standard deviation

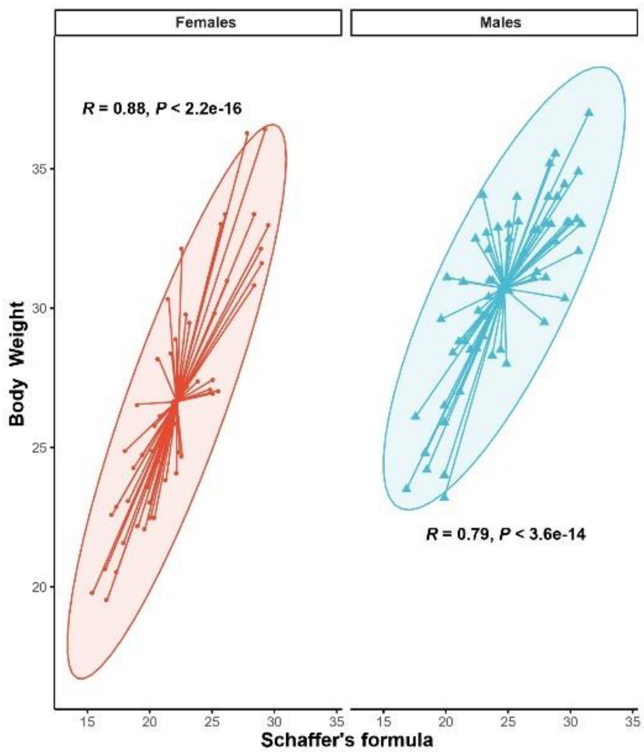

Figure 1. Association between live weights (observed) and estimates (obtained using Shaeffer's formula) in Black Belly sheep, by sex. Pearson's coefficients of correlation and correspondents p-values are included.

DISCUSIÓN

The determination of animal BW is the most important and essential economic factor for selection and production performance. Knowing the estimated BW can help with decisions such as which breed to use for a particular type of production. For example, wool or meat production. Estimation of BW in small ruminants is important for several reasons, including breeding, proper feeding and disease management for optimal health and productivity (Karna *et al*., 2022; Vazquez-Martinez *et al*., 2023).

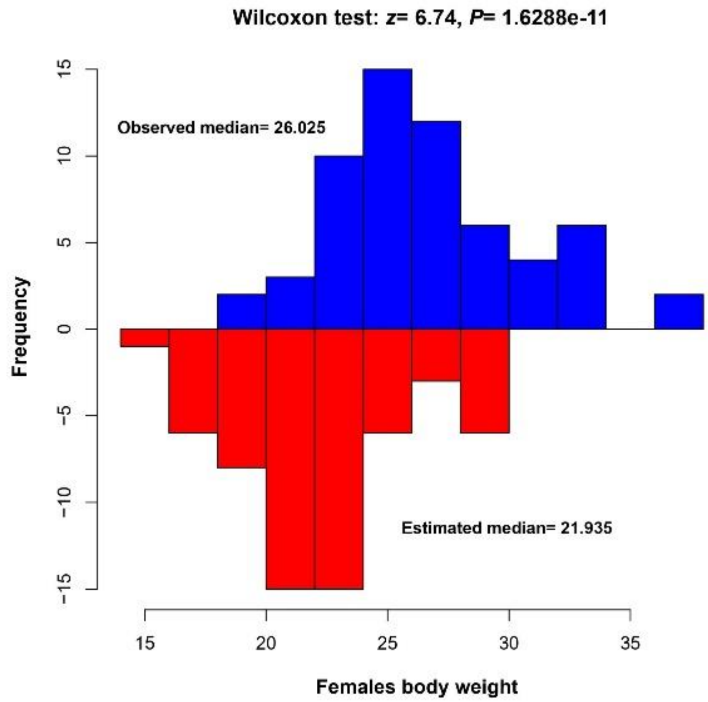

Figure 2. Comparison between live weights (observed) and estimates (obtained using Shaeffer's formula) in female Black Belly sheep. Medians for both sets and Wilcoxon signed rank test results are included.

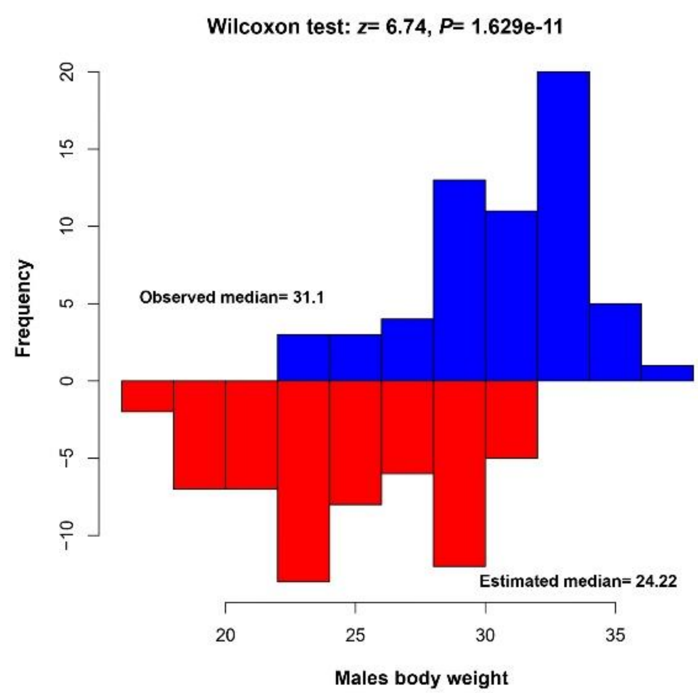

Figure 3. Comparison between live weights (observed) and estimates (obtained using Shaeffer's formula) in male Black Belly sheep. Medians for both sets and Wilcoxon signed rank test results are included.

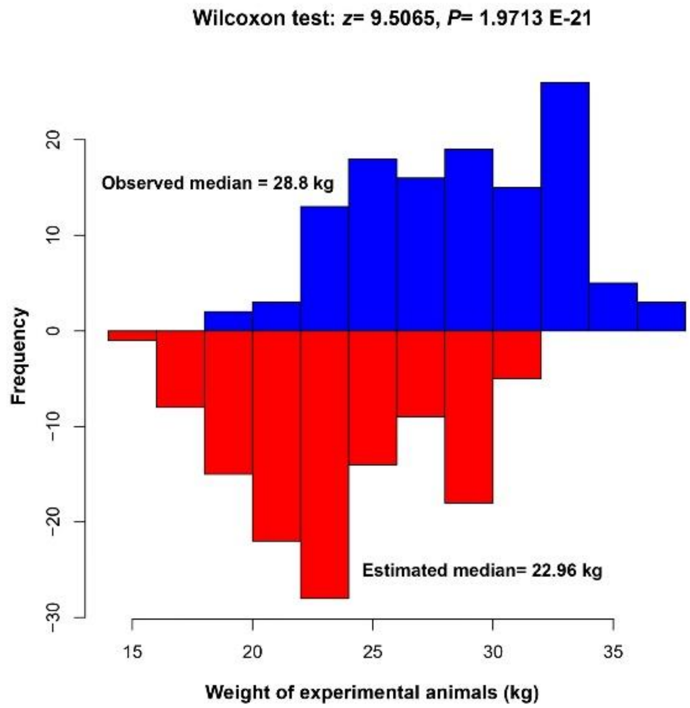

Figure 4. Comparison between live weights (observed) and estimates using Schaeffer's formula. Estimates for females (a), males (b) and all data (c). Corresponding medians and Wilcoxon signed rank test results are shown.

Regarding using the Schaeffer's formula to predict BW in different species, Navarro *et al.* (2023) found no significant differences between actual and formula-estimated BW in Zebu 322.36 vs. 313.67; Bradford 250.28 vs. 243.50; Brangus 259.09 vs. 248.30 and their crosses 333.11 vs. 324.87 kg. These authors found that there was a strong positive correlation between the true BW and the BW estimated by the Schaeffer formula (r≥0.94≤0.99). They also concluded that for estimating BW in beef cattle of the main biotypes used Schaeffer's formula was accurate. Vaidya *et al*. (2018) used Schaeffer's formula to predict BW in Osmanabadi goats and Deccani sheep, and found a significant difference between actual and predicted BW. It was also observed that the error in predicting BW increased with increasing age of the small ruminants. These authors observed an inaccuracy of Schaeffer's formula in small ruminants. For unspecified cows, buffaloes and calves, Schaeffer's formula consistently overestimated live BW for smaller animals. The opposite was true for heavier animals. Despite this, the authors suggest that farmers can use Schaeffer's formula to estimate BW with high accuracy for routine farm practices in the absence of a weighing platform (Riaz *et al*., 2018). In addition, Karna *et al*. (2022) reported that Schaeffer's formula overestimated BW in Ganjam goats across all age groups. In the present study it was observed that Shaeffer's formula underestimated BW in Black Belly sheep at about 5.84 kg. This weight represents about 20.40% of the observed mean BW. The underestimation was also much greater than expected in males at approximately 6.88 kg, this weight represents approximately 22.40% of the observed mean BW in males. However, for females the difference was 6.88 kg. This weight represents approximately 15.40% of the observed mean BW for females. There is a high level of variation and therefore not applicable. The Schaeffer's formula has been little used in hair sheep, such as the Black Belly breed. However, it has been used in other small ruminants with better results. In cattle, a species of zootechnical interest, this formula has been adequately adapted. Furthermore, although the aim is to predict the weight of the animals, the variations between the observed and expected values are high, which considerably limits the use of the Schaeffer's formula to predict BW in Black Belly sheep. This shows that this formula is not accurate in estimating BW in Black Belly sheep of different sex. Therefore, caution should be exercised when using the Schaeffer's formula to estimate BW in Black Belly sheep, or some adjustment to this equation should be evaluated to increase its precision and accuracy in predicting BW in hair sheep breeds.

CONCLUSIONS

Under the conditions in which the present study was carried out, it was concluded that Shaeffer's formula underestimated BW in Black Belly sheep. The estimated BW differed from the observed BW (P<0.05) and this parameter was underestimated much more than expected in males than in females, showing that this formula is not accurate in estimating BW in Black Belly sheep. There is a need to develop improved prediction equations for adequate estimation of BW in Black Belly sheep. Due to the limitations of the prediction, its use is not recommended.

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Compliance with ethical standards. The animals were treated in accordance with the guidelines and regulations for animal experimentation of the Academic Department of Agricultural Sciences of the Universidad Juárez Autónoma de Tabasco (authorisation code: CIEI: Folio 1173-2022).

Conflict of interest. The authors declare that there is no conflict of interest.

Data availability. Data are available with the corresponding author of this publication upon reasonable request.

Authors contribution statement (CRediT). P. Colorado-García: Investigation; Methodology, and Writing – original draft. **J.L. Ponce-Covarrubias:** Software, Supervision, Validation, Visualization, and Writing – original draft. **R.C. Barrientos-Medina:** Data curation, Formal Analysis, and Writing – original draft. **C.V. Zaragoza-Vera:** Supervision, Validation, Visualization, and Writing – original draft. **M. Zaragoza-Vera:** Conceptualization, Data curation, Writing – original draft, and Writing – review & editing. **O. Torres-Chable:** Supervision, Validation, Visualization, and Writing – original draft. **A.J. Chay-Canul:** Conceptualization, Data curation, Formal Analysis, Funding acquisition, Writing – original draft, and Writing – review & editing.

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