COMPARISON BETWEEN VISUAL ASSESSMENT AND MEASUREMENT OF HEART GIRTH OR HIP-WIDTH TO ESTIMATE LIVE WEIGHT IN CROSSBRED BEEF HEIFERS †

[COMPARACIÓN ENTRE LA EVALUACIÓN VISUAL Y LA MEDICIÓN DEL PERÍMETRO TORÁCICO O DEL ANCHO DE CADERA PARA ESTIMAR EL PESO VIVO EN NOVILLAS DE VACUNO CRUZADAS]

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SUMMARY

Background. Estimation of animal body weight (BW) is a fundamental tool in herd management for the development of reproductive, nutritional and health programmes. **Objective.** To compare the actual BW and its estimation by visual method and measurement of the heart girth (HG) or hip width (HW) for estimating BW in crossbred beef heifers reared under humid tropical conditions in Mexico. **Methodology.** Data on GH, HW, BW estimated by the visual method (MV) and actual BW were recorded in 105 crossbred replacement heifers (*Bos taurus* × *Bos indicus*) Swiss American, Beef Master, Simmental, and Brahman with different degrees of crossbreeding. Heifers ranged in age from three to 20 months and were grazed on star grass (*Cynodon nlemfuensis*) and humidicola grass (*Brachiaria humidicola*) pastures without supplementation. BW was recorded using a digital scale, HG was measured using a flexible fibreglass tape and HW was measured using a 65 cm forceps. BW by visual estimation was considered as the average of three observations made by three observers, HG and HW methods using the formula 1) BW (kg): $202.68 - 4.39 \times HG + 0.03 \times HG^2$; 2) BW (kg): $0.26 \times HW^{1.90}$. The Pearson coefficient and the distribution (density) of each variable, were assessed using a correlation matrix graph. Also, a comparison the measures obtained by each of the different estimation methods with the observed weights, by inspecting the paired Bland-Altman plots, prior to logarithmic transformation. **Results.** Correlations between observed BW and predicted BW for the HG, HW and visual methods showed a positive and significant relationship ($P<0.001$), with r values of 0.95, 0.89 and 0.92, respectively. The HG method tended to overestimate the real BW, whereas, in the visual and HW methods, the values are evenly and randomly distributed around the line, indicating that these methods neither underestimated nor overestimated the BW. **Implications.** Although the HG method showed the highest correlation coefficient between observed and predicted BW, the result of the present study showed that visual assessment highlights the ability of observers to

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visually estimate the BW of growing heifers. **Conclusion.** Livestock handlers have a very accurate estimation of BW. The use of alternative methods to scales, such as the HG measuring method, can be useful and practical tools to improve the accuracy of the assessment.
Keywords: Beef cattle; Live weight; Animal production; Accuracy.

RESUMEN

Antecedentes. La estimación del peso vivo (PV) de los animales es una herramienta fundamental en la gestión de rebaños para el desarrollo de programas reproductivos, nutricionales y sanitarios. **Objetivo.** Comparar el PV real y su estimación por método visual y medición del perímetro torácico (PT) o ancho de cadera (AC) para estimar el BW en vaquillas de carne cruzadas criadas bajo condiciones de trópico húmedo en México. **Metodología.** Se registraron datos de PT, AC y PV estimado por el método visual (MV) y el PV real en 105 vaquillas de reemplazo cruzadas (*Bos taurus* × *Bos indicus*) Swiss American, Beef Master, Simmental y Brahman con diferentes grados de cruzamiento. Las novillas tenían entre 3 y 20 meses de edad y pastaron en praderas de pasto estrella (*Cynodon nlemfuensis*) y pasto humidicola (*Brachiaria humidicola*) sin suplementación. El PV se registró con una báscula digital, la AC se midió con una cinta de fibra de vidrio flexible y el PT con una forcípula de 65 cm. El PV por estimación visual se consideró como la media de tres observaciones realizadas por tres observadores, métodos de peso corporal mediante las fórmulas 1) PV (kg): $202.68 - 4.39 \times PT + 0.03 \times PT^2$; 2) PV (kg): $0.26 \times AC^{1.90}$. El coeficiente de Pearson y la distribución (densidad) de cada variable se evaluaron mediante un gráfico de matriz de correlaciones. Asimismo, se compararon las medidas obtenidas por cada uno de los diferentes métodos de estimación con los pesos observados, mediante la inspección de los gráficos de Bland-Altman pareados, previa transformación logarítmica. **Resultados.** Las correlaciones entre el peso corporal observado y el predicho para los métodos PT, AC y visual mostraron una relación positiva y significativa ($P<0.001$), con valores r de 0.95, 0.89 y 0.92, respectivamente. A este respecto, el método PT tiende a sobrestimar el peso real, mientras que en los métodos visual y AC los valores se distribuyen de forma uniforme y aleatoria alrededor de la línea, lo que indica que estos métodos no subestiman ni sobrestiman el peso real. **Implicaciones.** Aunque el método PT mostró el mayor coeficiente de correlación entre el PV observado y el predicho, el resultado del presente estudio mostró que la evaluación visual pone de manifiesto la capacidad de los observadores para estimar visualmente el PV de las novillas en crecimiento. **Conclusiones.** Los operadores de ganado tienen una estimación muy precisa del PV. El uso de métodos alternativos a las básculas, como el método de medición PT, pueden ser herramientas útiles y prácticas para mejorar la precisión de la evaluación.
Palabras clave: Ganado vacuno; Peso vivo; producción animal; Precisión.

INTRODUCTION

In cattle production, the growth of replacement heifers is an important trait that must be constantly monitored because it affects the productive and reproductive performance of the adult cow (Heinrichs *et al*., 2017; Herrera-López *et al*., 2018; Castillo-Sanchez *et al*., 2022; Chico-Alcudia *et al*. 2022). Therefore, for the development of reproductive, nutritional and health programmes, the estimation of animal body weight (BW) is a fundamental tool of herd management (Castillo-Sanchez *et al*., 2022).

Although its importance for farm animal management and feeding decisions, BW is rarely recorded (or monitored) by smallholders due to the high cost of livestock scales (Wood *et al*., 2015). In general, assessing the growth of replacement heifers is a major challenge for smallholders, so they resort to estimating the weight of cattle without using to validated weighing methods. This results in animals being sold through negotiation or based on visual estimation, leading to high errors in BW estimation, which ultimately affects producers' economic profit (Wood *et al*., 2015; Castillo-Sanchez *et al*., 2022; Chico-Alcudia *et al*., 2022).

Some studies in tropical replacement heifers have shown that the heart girth (HG) can be a reliable, practical, and economical method to estimate BW in tropical crossbred beef heifers (Chico-Alcudia *et al*., 2022). In the same way, Herrera-López *et al*. (2018) have shown that the hip width of crossbred beef heifers can be used with high precision to estimate BW. Therefore, the aim of this study was to compare the actual BW and their estimation trough visual method and the measurement of heat girth (GH) or hip width (HW) in crossbred beef heifers.

MATERIALS AND METHODS

Animals and management

The animals were treated according to the Academic Department of Agricultural Sciences of the Juarez Autonomous University of Tabasco guidelines and regulations for animal experimentation. In vivo animal research guidelines were followed for all methods (Percie du Sert *et al*., 2020).

Data on heart girth (HG), hip width (HW), visual assessment of body weight (BW) and actual BW were recorded from 105 crossbred beef heifers (Bos taurus × Bos indicus) Beef Master, Simmental and Brahman with varying degrees of crossbreeding. The number of animals included in the study was determined because they were the animals on the farm that met the inclusion criteria. The heifers ranged in age from 3 to 20 months and were grazed on star grass (*Cynodon nlemfuensis*) and humidicola grass (*Brachiaria humidicola*) pastures without supplementation, also water and mineral licks were also available.

The BW was recorded using a digital scale, and HG was measured using a flexible glass fibre tape (Truper®, Mexico) and HW using a 65cm callipers. Visual estimates of each animal's weight were recorded, first by an animal science researcher and then by two producers with approximately 25 years of experience in keeping and handling cattle. As described by Woods *et al*. (2015), each estimate was blinded to the other participants. The mean of the three recordings was taken as the visual estimate. The equation proposed by Chico-Alcudia *et al*. (2023) using HG for BW prediction and the equations proposed by Herrera-Lopez *et al*. (2020) using HW are used to predict BW in crossbred beef heifers (Table 1).

Statistical analysis

The relationships between the values obtained by the estimation methods and the observed weights, including the value of the Pearson coefficient and the distribution (density) of each variable, were assessed using a correlation matrix graph. Then, the obtained measures were compared by each of the different estimation methods with the observed weights and this was performed by inspecting the paired Bland-Altman plots, prior to logarithmic transformation (Bland and Altman, 2009). This is justified by the biases identified in the first part of the analysis. All the graphs and calculations were carried out in the R programming environment (R Core Team, 2023), version 4.3.0.

RESULTS

Table 2 shows the descriptive statistics of mean, minimum and maximum BW, HG and HW of heifers reared under humid tropical conditions. The mean BW was 386.04±80.46 kg, HG was 171.52±13.60 cm and HW was 45.56±5.99 cm. The coefficients of variation for BW, HG and HW were 20.84%, 7.93% and 13.16%, respectively. This is an indication of a normal distribution, as none of the coefficients of variation is greater than 30%.

Correlations between observed and predicted BW for the HG, HW and visual methods showed a positive and significant relationship ($P<0.001$), with r values of 0.95, 0.89 and 0.92 respectively (Figure 1). It can also be seen that they are practically normal, which is an indication that they are good predictors of the measurement variables. In Figure 2, the line of equality indicates where the points would fall if the two methods agreed. In this sense, when comparing the different methods, the size of the distance from the line is a measure of the size of the error. The points above or below the line indicate underestimation or overestimation compared to the reference weight. In this respect, the HG method tended to overestimate the real BW, whereas, in the visual and HW methods, the values are evenly and randomly distributed around the line, indicating that these methods neither underestimate nor overestimate BW (Figure 2). However, when comparing the methods, according to the Bland-Altman plot, the bias seems to be constant, with a slight widening of the limits of agreement, indicating a good correlation ($r>0.90$) between the methods (Figures 3, 4 and 5).

Table 1. Body weight prediction equations for heifers using hearth girth or hip width.

No.	Equation	n	R^2	RMSE	Reference
1	BW (kg): $202.68 - 4.39 \times HG + 0.03 \times HG^2$	400	0.97	27.13	Chico-Alcudia *et al*. (2023)
2	BW (kg): $0.26 \times HW^{1.90}$	500	0.97	23.55	Herrera-López *et al*. (2018)

BW = Body weight (kg); HG = hearth girth (cm); HW = hip width (cm); n = number of observations; r^2 = coefficient of determination; RMSE = root mean square error.

Table 2. Minimum and maximum values of BW, hearth girth (HG) and hip width (HW) of heifers kept under humid tropical conditions.

Variable	Description	Mean	SD	Minimum	Maximum
BW	Body weight (kg)	386.04	80.46	250.00	598.00
HG	Hearth girth (cm)	171.52	13.60	150.00	209.00
HW	Hip width (cm)	45.56	5.99	34.00	65.00

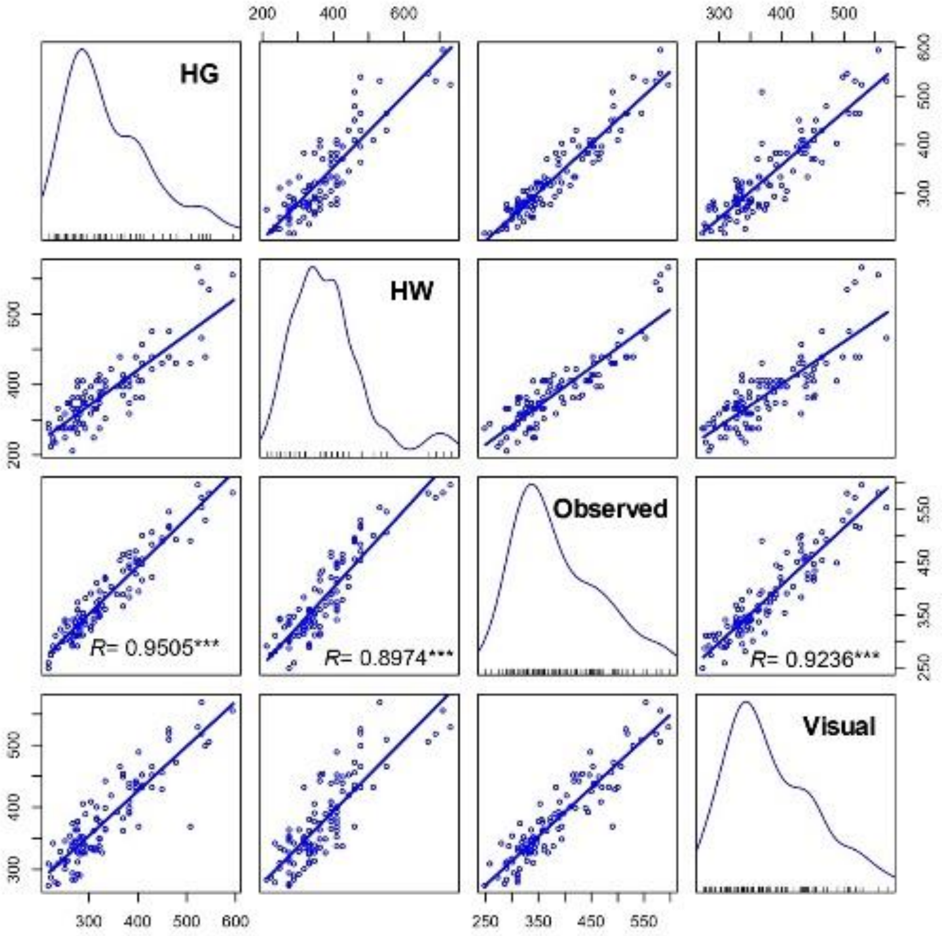

Figure 1. Correlation matrix between observed BW and predicted BW for the HG, HW and visual methods.

DISCUSSION

As an alternative to the use of livestock scales, this study compared the reliability of visual assessment by measuring heart girth or hip width to estimate body weight in heifers. In this sense, van Dijk, *et al*. (2015) explained that this can lead to underdose drugs when animals require treatments. Otte *et al* (1992) observed that in animals weighing over 200 kg, the mean difference between the scale and tape weight estimates was between 2 to 9 kg, and there was no statistically significant difference between the two methods, suggesting that the tape estimate could be between 12% below and 14% above the scale reading. According to Woods *et al*. (2015), visual estimation was variable in accuracy when estimates were compared with an indirect measure of BW. They also observed that underestimation appeared to occur more often with higher BW. Also, Málková *et al*. (2021) and Salazar-Cuytun *et al*. (2022) reported the limitations of weighing equipment in traditional production systems mean that animals are sold by negotiation or based on visual assessment, which leads to high errors in estimating BW. This ultimately affects the economic profits of producers. In this regard, Tebug *et al*. (2018) reported that farmers and livestock traders often rely on visual judgement to determine the BW of livestock, a subjective method where accuracy depends on the experience of the user. This aspect is consistent with the results of the present study. However, it differs from the conclusion of van Dijk *et al*. (2015), who found that a better method for determining the weight of modern dairy cattle is needed by veterinarians at all levels of experience, especially by farmers. Visual assessment can be effective under some conditions for animal management.

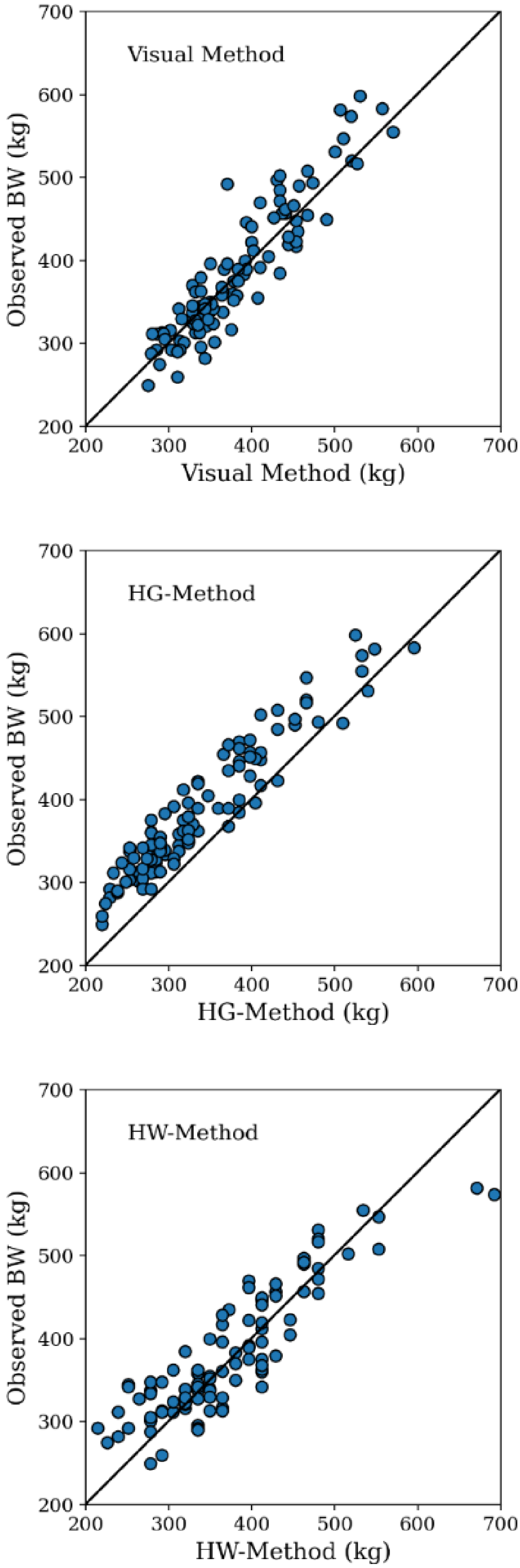

Figure 2. Scatter plot of observed BW and predicted BW for the HG, HW and visual methods.

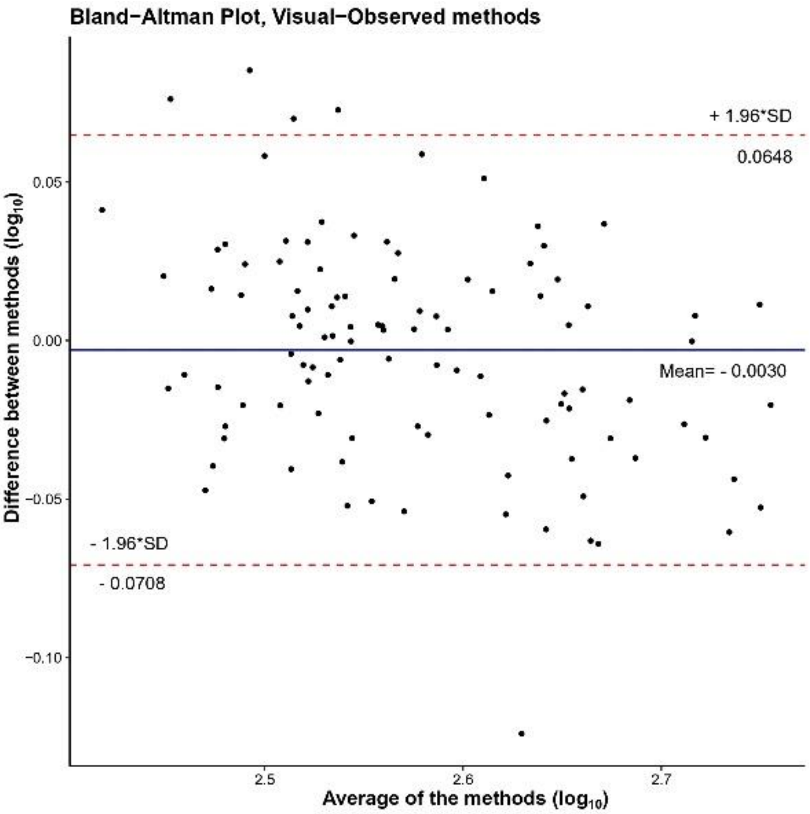

Figure 3. Bland–Altman plot showing the magnitude of differences in the results of the of actual weight (*y*-axis) against a mean of visual method (*x*-axis) using log10 transformed data, with line of best fit and 95% confidence intervals.

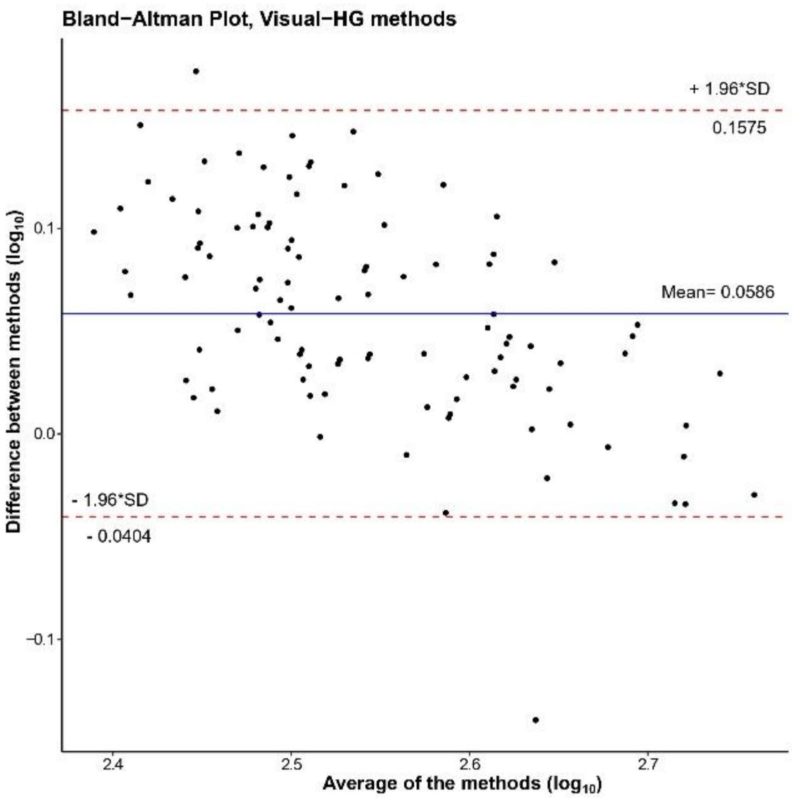

Figure 4. Bland–Altman plot showing the magnitude of differences in the results of the of actual weight (*y*-axis) against a mean of HG-method (*x*-axis) using log10 transformed data, with line of best fit and 95% confidence intervals.

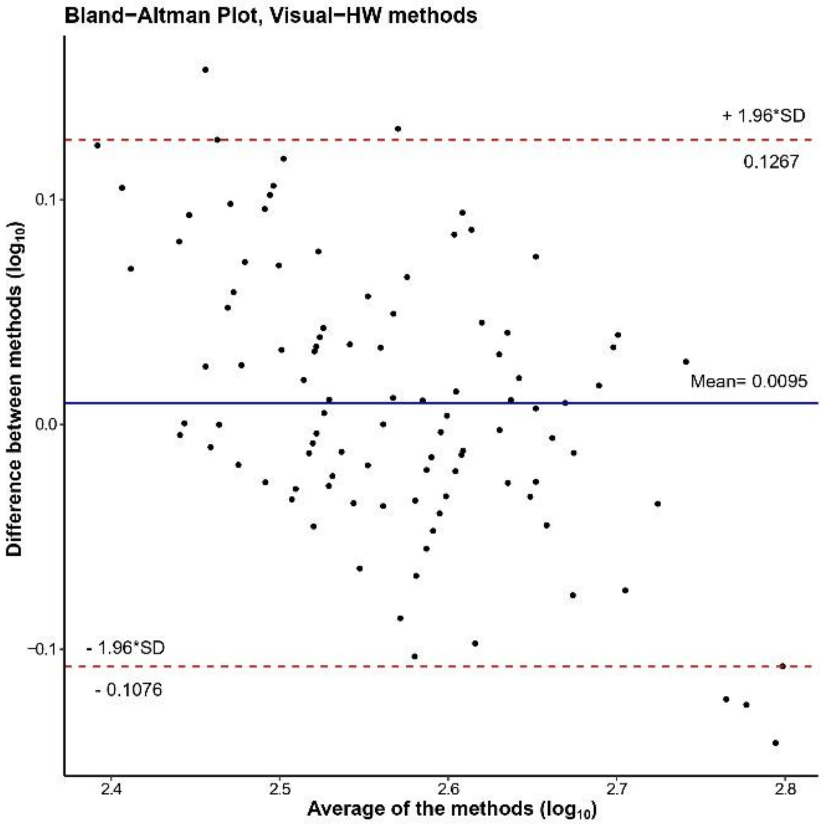

Figure 5. Bland–Altman plot showing the magnitude of differences in the results of the of actual weight (*y*-axis) against a mean of HW-method (*x*-axis) using log10 transformed data, with line of best fit and 95% confidence intervals.

CONCLUSIONS

Although the HG method showed the highest correlation coefficient (r>0.90) between observed and predicted BW, the result of the present study showed that visual assessment highlights the ability of observers to visually estimate the BW of growing heifers. The use of alternative methods to scales, such as the HG measuring method, can be useful and practical tools to improve the accuracy of the assessment.

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Compliance with ethical standards. Animals were handled according to the guidelines and regulations for animal experimentation of the Academic Division of Agricultural Sciences of the Universidad Juárez Autónoma de Tabasco (ID project PFI: UJAT-DACA-2015-IA-02).

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). **M.I. Alejandro-Zarate:** Investigation; Methodology, and Writing – original draft. **R. Salazar-Cuytun:** Software, Supervision, Validation, Visualization, and Writing – original draft. **J. Herrera-Camacho:** Validation, Visualization, and Writing – original draft. **A. Cruz-Hernández:** Supervision, Validation, Visualization, and Writing – original draft. **R.C. Barrientos-Medina:** Data curation, Formal Analysis, and Writing – original draft. **M. Ptáček:** Conceptualization, Data curation, Writing – original draft, and Writing – review & editing. **E. Vargas-Bello-Pérez:** Conceptualization, Data curation, Writing – original draft, and Writing – review & editing. **A.J. Chay-Canul:** Conceptualization, Data curation, Formal Analysis, Funding acquisition, Writing – original draft, and Writing – review & editing

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