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Morphometric evaluation of guinea pigs (*Cavia Porcellus*) in Southern Peru

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Abstract: The aim of this study was the morphometric evaluation of guinea pigs in southern Peru. The study was carried out at the Agrarian Experimental Station Illpa (AESI) of the National Institute of Agrarian Innovation (NIAI) in Puno at 3824 meters above sea level. 120 guinea pigs were used (females n = 60 and males n = 60) with an average age of 22 days. The morphometric characteristics evaluated were: body weight (BW), chest circumference (CC), abdominal perimeter (AP), neck perimeter (NP), head length (HL) and head width (HW). To evaluate the effect of sex on morphometric characteristics, a completely randomized design was used. To determine the equation that best predicts body weight, stepwise regression was used, and correlations between morphometric characteristics were obtained using Pearson's correlation. The results show that the sex factor does not significantly influence BW, CC, AP, NP, HL, and HW ($p \geq 0.05$); likewise, the equation that best predicts the body weight of the guinea pigs was: BW = -530.50 + 21.98(CC) + 12.72(AP) + 10.16(NP) + 57.23(HW), with R^2 = 84%. Pearson correlations between morphometric characteristics were of high magnitude, positive, and statistically significant ($p<0.001$). It is concluded that in conditions of the Peruvian highlands, the sex factor does not influence the morphometric characteristics. It is also possible to predict body weight from CC, AP, NP, and HW, and the correlations were high and positive.

Keywords: *Abdominal perimeter, Body weight, Guinea pigs, Head length, Head width, Morphometric characteristics, Neck perimeter, Southern Peru, Stepwise regression.*

1. Introduction

The guinea pig (*Cavia porcellus*) is a mammal, monogastric herbivore, native to South American countries such as Peru, Ecuador, Bolivia, and Colombia. They are raised mainly for meat production [1].Guinea pig meat is considered an important source of protein, with significant potential to be included in the human diet, especially in regions where it is already accepted for consumption [2]. Morphometry can reveal significant differences in body measurements between sexes and age classes in animal species, helping to understand their biology and ecology [3]. The goal of this study was to evaluate the morphometric characteristics of guinea pigs from southern Peru.

2. Literature Review

Cruz, et al. [4] in a study carried out on guinea pigs from the Saños and Mantaro genetic lines, indicate that the sex of the guinea pig does not influence the weight at weaning.Male guinea pigs have a slightly higher weight than females both at birth and at weaning, indicating that sex can influence weight at weaning [5, 6]. Researchers report that sex does not have a significant influence on the weaning weight of Cieneguilla guinea pigs, located on the central coast of Peru.Sex has a significant effect on body weight and linear body measurements in guinea pigs, with males generally being heavier than females [5, 7-10]. It is reported that the sex of the guinea pig does not influence the variables:

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body weight, head-body length, chest circumference, neck circumference, and head circumference. However, it significantly influences left ear length and left hind foot length, under conditions in the country of Benin. In a study carried out on 90-day-old Cieneguilla guinea pigs, it was determined that the independent variables that best predicted carcass weight were the thoracic perimeter, length of the back, and width of the head, with a precision greater than 70%.In guinea pigs, chest circumference and head and body length are measurements used to predict body weight, with multiple regression models [10, 11].

3. Materials and Methods

3.1. Study Location

This study was carried out at the Agrarian Experimental Station Illpa(AESI), which belongs to the National Institute of Agrarian Innovation (NIAI), located in the district of Paucarcolla, province of Puno, geographical region of Puno; at 3824 meters above sea level, with geographical coordinates Latitude: 15°40'55.53"S and Longitude: 70°4'31.89"W, with an annual average maximum and minimum temperature of 9.7°C and 4.2°C, respectively, with an average annual rainfall of 710 to 719 mm and a relative humidity between 50.4 and 64.3%.The Agrarian Experimental Station Illpa(AESI)has a shed for guinea pigs that is built from brick and cement and has a capacity of 1,000 guinea pigs. It also has a biosecurity program.

3.2. Animals

The guinea pigs were managed following the recommendations of Peruvian legislation through National Law No. 30407, "Animal Protection and Welfare Law." 120 guinea pigs of the Peru breed were used, of which 60 were males and 60 were females, with an average age of 22 days, clinically. The guinea pigs were fed balanced food with 18% protein; daily, they received 17 grams of balanced food and water ad libitum.

3.3. Measurements

The morphometric measurements were carried out in a live animal. The variables were: body weight (BW), for this, an EXCELL® electronic scale was used with a capacity of 5000 grams and a precision of 2 grams, chest circumference (CC), perimeter abdominal (AP), neck perimeter (NP), head length (HL) and head width (HW). CC, AP, and NP were measured using a tape measure. HL and HW were measured using a Kamasa® digital caliper with a precision of 0.01mm.

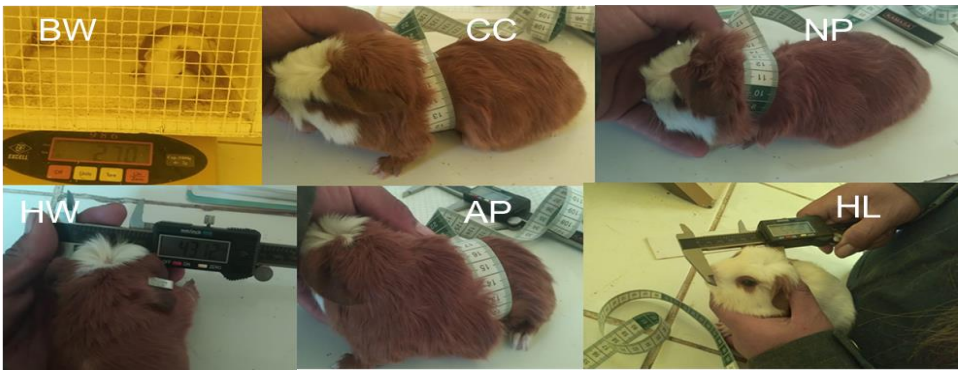

Figure 1.
Morphometric measurements evaluated in guinea pigs.

Figure 1 illustrates the morphometric measurements in guinea pigs: body weight (BW), chest circumference (CC), neck perimeter (NP), head width (HW), abdominal perimeter (AP), and head length (HL).

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3.4. Statistical Analysis

To evaluate the effect of sex on morphometric characteristics, a completely randomized design was used; to determine the equation that best predicts body weight, stepwise regression was used, and correlations between morphometric characteristics were obtained using Pearson's correlation, which were analyzed with the R Core Team [12].

4. Results and Discussions

4.1. Effect of Sex on Morphometric Characteristics

The analysis of variance (ANOVA), along with the results of the Tukey test, indicates that means marked with identical letters suggest the absence of a statistically significant difference in body weight and various biometric variables at weaning between male and female groups ($p \geq 0.05$) Table 1. This suggests that although the means may not differ significantly between males and females, the variability in these biometric measures is more pronounced in males compared to females.

Table 1.
Descriptive statistics of the effect of sex on morphometric characteristics in guinea pigs (Mean ± standard deviation).

Morphometric measures	Female (n = 60)	Male (n = 60)
Body weight (BW), g	269.25 ± 64.85 [a]	295.03± 89.97[a]
Chest circumference (CC), cm	13.27± 1.44 [a]	13.78± 1.64 [a]
Abdominal perimeter (AP), cm	17.03 ± 1.69 [a]	17.60± 2.24 [a]
Neck perimeter (NP), cm	10.86± 1.02 [a]	10.83± 1.24 [a]
Head length (HL), cm	5.56± 0.26 [a]	5.64± 0.30 [a]
Head width (HW), cm	3.21± 0.16 [a]	3.26± 0.24 [a]

Note: n: Number of animals.
[a] Letters with the same superscript indicate statistically equal values; denotes non-significant differences ($p \geq 0.05$).

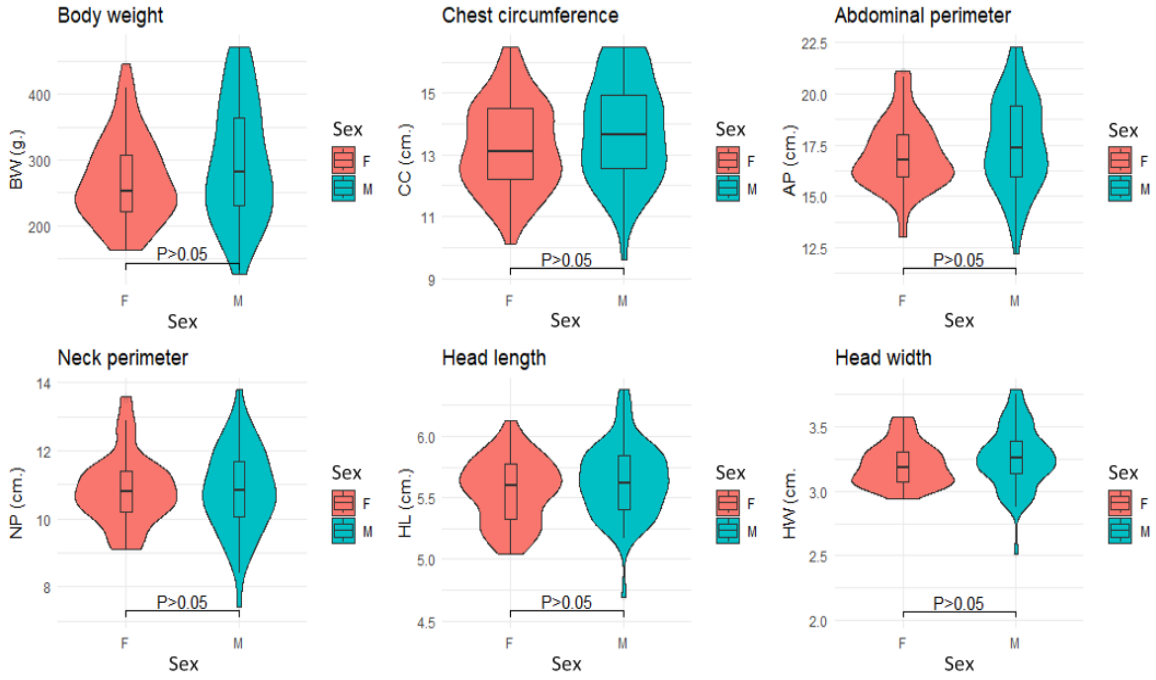

Figure 2.
Graph illustrating the influence of sex on body weight and other morphometric characteristics in guinea pigs.

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Figure 2 illustrates the violin plot for body weight (BW), chest circumference (CC), neck perimeter (NP), head width (HW), abdominal perimeter (AP), and head length (HL) according to the sex of the guinea pig (M: male and F: female). No significant differences are observed ($p>0.05$).

Similar results were reported by Cruz, et al. [4]; Rodríguez L, et al. [6]; Rubio [9] and Ogah [11] which indicate that the sex of the guinea pig does not influence the weight at weaning, chest circumference or neck circumference. While other results indicate that sex has a significant effect on body weight and body measurements in guinea pigs, with males generally being heavier than females [5, 7, 8].

4.2. Body Weight Prediction

These data correspond to male and female guinea pigs in the weaning stage, providing a comprehensive view of the distribution and variability of the biological characteristics under study (Table 2).

Table 2.
Descriptive statistics of body weight prediction in guinea pigs (Mean ± standard deviation).

Morphometric measures	Female and male (n = 120)
Body weight (BW), g	269.25 ± 64.85
Chest circumference (CC), cm	13.27± 1.44
Abdominal perimeter (AP), cm	17.03±1.69
Neck perimeter (NP), cm	10.86± 1.02
Head length (HL), cm	5.56± 0.26
Head width (HW), cm	3.21± 0.16

Note: n: Number of animals.

The analysis of various multiple regression models is presented, each composed of different combinations of predictor variables (CC, AP, NP, HL, and HW) in relation to the dependent variable (BW). It yielded results that provide deep and valuable insights (Table 3). In particular, Model 1, incorporating the majority of predictor variables, stands out with the lowest BIC (1191.09) and the highest adjusted R^2 (0.84). These indicators suggest that this model achieves an optimal balance between fit quality and simplicity.

Table 3.
Stepwise multiple regression equations to predict body weight in guinea pigs.

Model	Predictors	BIC	R^2adj.	Models
1	CC AP NP HW	1191.09	0.84	BW = -530.50 + 21.98(CC) + 12.72(AP) + 10.16(NP)+ 57.23(HW)
2	CC AP HW	1193.38	0.84	BW = -515.82 + 24.84(CC) + 14.46(AP) + 65.43(HW)
3	CC AP NP	1194.69	0.83	BW = -427.24 + 24.98(CC) + 14.01(AP) + 11.98(NP)
4	CC AP NP HL HW	1195.85	0.83	BW = -523.01 + 22(CC) + 12.77(AP) + 10.13(NP)- 2.21(HL)+58.45(HW)
5	CC AP HL HW	1198.09	0.83	BW = -504.42 + 24.87(CC) + 14.54(AP) – 3.38(HL) + 67.26(HW)
6	CC AP NP HL	1198.93	0.83	BW = -464.95 + 24.65(CC) + 13.69(AP) + 11.85(NP) + 8.60(HL)
7	CC AP	1199.08	0.82	BW = -391.87 + 28.94(CC) + 16.33(AP)
8	CC AP HL	1203.30	0.82	BW = -432.16 + 28.57(CC) + 15.98(AP) + 9.16(HL)
9	CC NP	1217.00	0.80	BW = -539.47 + 27.95(CC) + 16.84(NP)
10	CC NP HL HW	1221.50	0.80	BW = -563.8 + 27.80(CC) + 16.83(NP) + 7.21(HL) + 76.41(HW)

Note: BIC: Bayesian information criterion; $R^2_{adj.}$: Adjusted coefficient of determination.

The regression equation reveals that CC, AP, NP, and HW significantly influence the BW. Each coefficient represents the average change in body weight per unit change in the corresponding variable, while keeping the others constant. The statistical significance of the coefficients ($p < 0.05$) and the adjusted R^2 of 0.84 indicate that the model explains 84% of the variability in body weight, suggesting a

good fit. To draw robust conclusions, however, it is essential to consider the model's limitations, such as the assumptions of linearity and the dependence on specific study conditions.

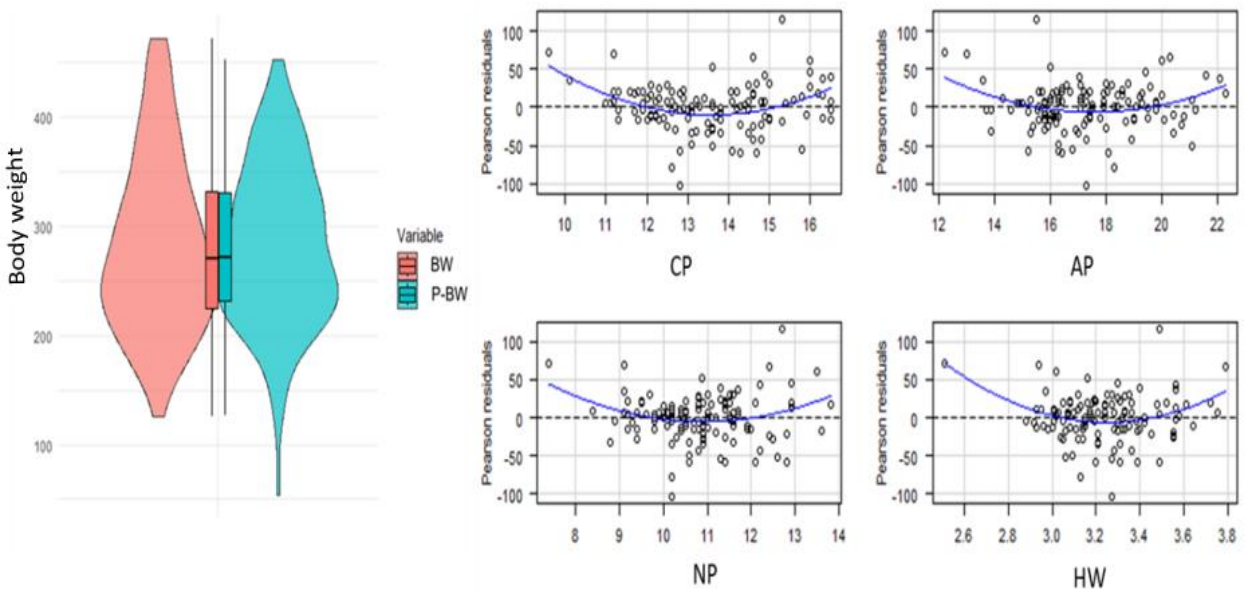

Figure 1.
Graph of actual body weight and predicted body weight from model 1.
Note: Points that deviate significantly from zero are outliers that influence the model.

Figure 3 illustrates the observed body weight (BW) and predicted body weight (P-BW) based on model 1.

Comparing these findings with previous research, such as those of Rubio [9]; Rodriguez [13] and Montes-Vergara, et al. [14] supports the inclusion of CP and AP as key predictor variables in the proposed regression equation. The contribution of Shahinfar, et al. [15] represents an innovation in prediction, standing out for the use of machine learning algorithms.

The results suggest that the optimal equation for predicting body weight in guinea pigs and other species may vary depending on the specific characteristics of each study and the animal population. Although the model demonstrates a significant fit and explains 84% of the variability in body weight, it is crucial to consider the specific context and study conditions.

The selection of key variables, taking into account factors such as sex and species, is essential for developing accurate and applicable prediction equations in various animal production contexts.

4.3. Pearson Correlation between Morphometric Characteristics

In Figure 4, the Pearson correlation coefficients among various biometric measures are presented, all of which were positive and statistically significant ($p < 0.001$). These measures include body weight (BW), chest circumference (CC), abdominal circumference (AC), neck circumference (NC), head width (HW), and head length (HL).

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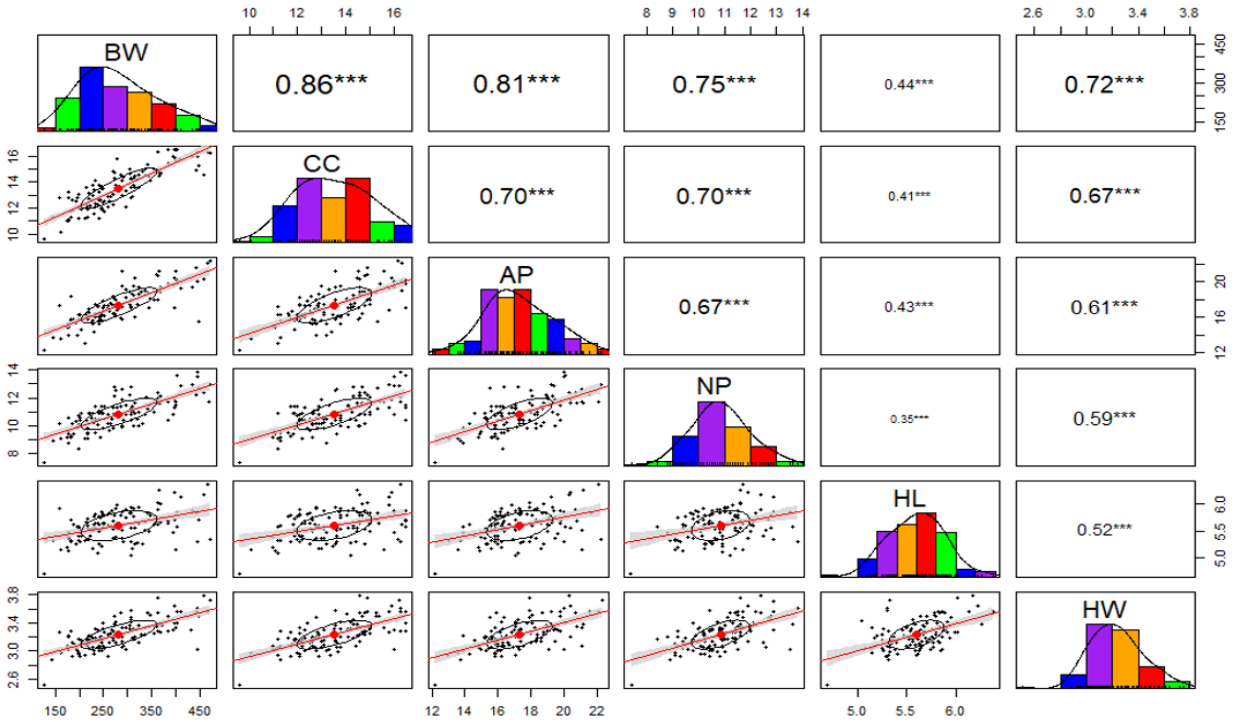

Figure 4.
Pearson correlation graph between morphometric characteristics in guinea pigs.
Note: ***: ($p<0.001$).

The variability in correlations underscores the complexity and diversity in the anatomical development of weaned guinea pigs, where different body regions may respond uniquely to genetic, environmental, or nutritional factors. The results of this study support and complement previous research, consolidating the importance of chest circumference and other morphological variables in predicting body weight across different animal species. These findings contribute to field's knowledge may have practical applications in animal population management and evaluation.

5. Conclusion

- The sex factor does not have a significant influence on the morphometric characteristics of 22-day-old guinea pigs.
- The model that best predicts the BW of 22-day-old guinea pigs consists of four morphometric measurements: CC, AP, NP, and HW, with a coefficient of determination (R^2) of 84% and is statistically significant.
- The Pearson correlations between the morphometric characteristics of the guinea pigs at 22 days of age were high, positive, and statistically significant.

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Institutional Review Board Statement:
The authors assert that the protocol used to conduct the morphometric measurements is of conventional application and is used internationally, in compliance with the requirements of National Law No. 30407, the "Animal Protection and Welfare Law," which has been in effect in Peru since January 8, 2016.

Transparency:
The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

Competing Interests:
The authors declare that they have no competing interests.

Authors' Contributions:
All authors contributed equally to the conception and design of the study. All authors have read and agreed to the published version of the manuscript.

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