Method of typification of the growth curve of the Andean guinea pig with the logistic model

Método de tipificación de la curva de crecimiento del cuye raza Andina con el modelo logístico

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Abstract

For the characterization of the growth curve first weight was measured from birth to slaughter 50 Cuyes data needed in the formulates of the logistic model. Microsoft Excel is used to plot the trend curve and return coefficient of determination given with each movement of factors A, K and B; the accuracy of the model, then the model with factors Curve Expert 1.6 software version is confirmed and finally a One Way ANOVA statistical test is performed to verify that the models are statistically no difference. A growth curve for Andean guinea pigs breed, adapted to the study region with a prescribed diet is typified; no statistical difference between the logistic model from the actual data found. This model can predict weight gain reliably, over the life of production cuye.

Biomodeling, Pattern, Animal production, Birth, Weaning, Sacrifice, Minitab, Excel, Curve expert

Resumen

Para la tipificación de la curva de crecimiento primero se midió el peso desde el nacimiento hasta el sacrificio de 50 Cuyes, datos necesarios en la fórmula del modelo logístico. Se utiliza Microsoft Excel para graficar la curva de tendencia y restablecer el coeficiente de determinación que dará con cada movimiento de los factores A, K y B; la exactitud del modelo, posteriormente se confirma los factores del modelo con un software Curve Expert versión 1.6 y por último se realiza una prueba estadística de ANOVA Unidireccional, para verificar que los modelos sean estadísticamente sin diferencias. Se tipifico una curva de crecimiento para cuyes raza andina, adaptada a la región de estudio con una dieta preestablecida; no se encontró diferencias estadísticas entre el modelo logístico respecto a los datos reales. Este modelo puede predecir la ganancia de peso en forma confiable, a lo largo de la vida del cuye en producción.

Biomodelación, Modelo, Producción animal, Nacimiento, Destete, Sacrificio, Minitab, Excel, Curve expert

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Introduction

Animal growth can be replicated through the use of mathematical functions, which predict the evolution of live weight over time, allowing evaluations to be made of the level of production in livestock farms, and the productivity of a specific breed for a given area can be classified in a simple way (Parks, 1982).

The various sigmoidal mathematical models model both population and individual growth (Noguera et al., 2008), the logistic model and the Von Bertalanffy model, among others, belong to the family of equations that can be broken down in the function of

Richards (Richards, 1959), and are frequently used for the adjustment of individual growth curves in the biological field (Garcia, 2005).

The Gompertz, Logistic, Richards, Bertalanffy and Brody models are the most frequently used growth functions to describe the growth of animal plants and organs. These models present three parameters with biological interpretation and one defined as a mathematical constant. Parameter "A" corresponds to the asymptotic weight or adult weight, representing the estimate of the weight at maturity. The parameter "K" corresponds to the maturity index or the estimate of maturity precocity (Nobre et al., 1987). The higher the value of this parameter, the earlier the animal and vice versa (Brown et al., 1976).

Formula logistic model (Verhulst, 1838):

$$y = \frac{A}{(1+K*e^{(-B*x)})}$$

The formula of the logistic model considers these factors with the following denomination: Parameter "A" Corresponds to the asymptotic weight or adult weight, represents the estimate of weight at maturity. Parameter "K" corresponds to the maturity index or the estimate of maturity precocity. The higher the value of this parameter, the earlier the animal is and vice versa. The parameter "B" is called integration parameter and has no biological significance.

The parameter "x" corresponds to the independent variable Time expressed in x unit of time (days, weeks, months, etc.). The parameter "y" is the weight when "x" tends to a finite value.

The existence of varieties of guinea pig breeds focused on different productive factors such as rapid weight gain or greater number of offspring per parturition, among others, together with the growing international demand for guinea pig meat, amply justifies the typification of its growth equation, of a logistic type, as well as the prior determination of the productive factors of the model on the Andean Guinea pig (Solari, 2010).

In work with guinea pigs, the average number of live and weaned offspring per parturition was 3.46±1.4 and 2.51±1.29, respectively. Birth weight and weaning weight averaged 86.7±21.6 g and 167.9±24.6 g, respectively. The averages found for live weight, carcass weight and carcass yield for 5-month-old non-fasting males were 955±106 g, 420±54 g and 43.98±3 % (Xicohtencatl et al., 2013).

In contrast, Chauca (1997) found birth and weaning weights of 121±2.4 g and 310±6.53 g, respectively. Apráez-Guerrero et al. (2009) reported average birth and weaning weights of 130.28±12.73 g and 259.69±14.46.

Material and methods

The guinea pigs were measured at the farm of the Escuela Secundaria Técnica No. 2 SEPEN, located in the Municipality of Xalisco, Nayarit, Mexico. The farm has 100 Andean breed (between first and 4th parturition) Andean breed guinea pigs with continuous postpartum mating in jal block stalls and cement floor; fed free access with pelleted feed (with 18 % crude protein, with Tanzanian forage with a crude protein percentage of 4.64 % grown on the farm, orange waste obtained from businesses that sell juices from the neighboring market and water.

For the typification of the growth curve, the birth weight of 50 guinea pigs was measured first, and in the following days until slaughter, as shown in Table 1.

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1. The data were normalized and averaged to reduce the experimental error.

Edad (Dias)	Peso (grs.)
1	88.27
8	143.08
11	169.97
16	210.77
23	250.77
30	285.38
60	546.80
91	805
150	950.00

Table 1 Andean guinea pig weights per day

Determining the initial parameters of the logistic model A, K and B, the parameter K, which in this case K = 6.19 and the natural logarithm of the slope will give the initial value of the constant of integration B, which in this case B= 1.82.

In the case of the constant of integration we will always use very small values (fractions less than 1) and they can even be negative.

These values will be used in the formula of the logistic model in a fixed way varying only the value of "x" (days) to determine the modeled data and subsequently determine its coefficient of determination and standard error. If the model is not adequate, we will adjust the factors again and recalculate the accuracy values and so on.

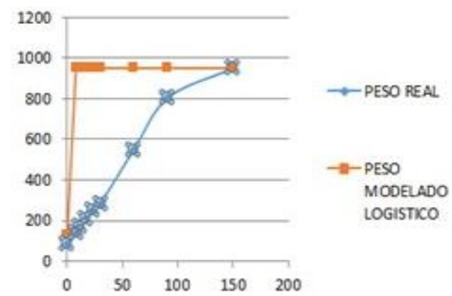
To facilitate this work, Microsoft Excel is used to plot the trend curve and restore the coefficient of determination that will give with each movement of the factors A, K and B; the accuracy of the model, then the factors of the model are confirmed with a software Curve Expert version 1.6 and finally a statistical test of One-way ANOVA is performed, to verify that the models are statistically without differences.

Plots showing the projection of the modeled values with the initially calculated factors.

Factores	
A	950
K	6.19
B	1.82

EDAD (días)	PESO REAL (Gr)	PESO MODELADO LOGISTICO (Gr.)
0	88.27	132.13
8	143.08	950.00
11	169.97	950.00
16	210.77	950.00
23	250.77	950.00
30	285.38	950.00
60	546.80	950.00
91	805	950.00
150	950.00	950.00

Table 2 Modeled vs. Actual Data



Graphic 1 Initial vs Actual logistic model

An improvement of the model can be observed, which already has an accuracy of 60% over the real data model.

In this first approximation a very inaccurate model can be determined and we must make adjustments to the slope and constant of integration, the first thing would be to adjust the constant and integration to a value fraction less than one.

Factores	
A	950
K	6.19
B	0.08

EDAD	PESO REAL	PESO MODELADO LOGISTICO
0	88.27	132.13
8	143.08	222.80
11	169.97	266.29
16	210.77	349.13
23	250.77	479.05
30	285.38	608.37
60	546.80	903.95
91	805	945.96
150	950.00	949.96

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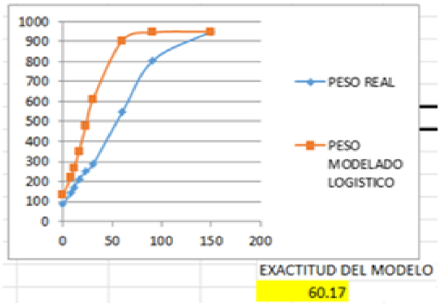
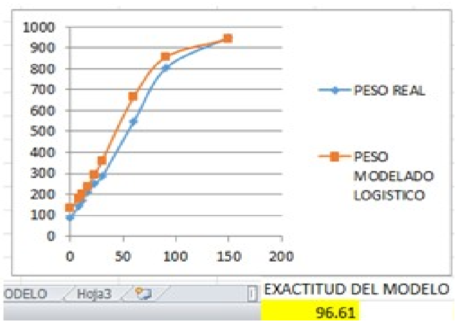


By simply adjusting the integration factor, a good fit is obtained, now that same factor is lowered to 0.0445.

Factores	
A	950
K	6.19
B	0.0445

EDAD	PESO REAL	PESO MOD LOGISTICO
0	88.27	132.13
8	143.08	178.04
11	169.97	198.16
16	210.77	235.31
23	250.77	294.64
30	285.38	361.36
60	546.80	664.95
91	805	857.48
150	950.00	942.64

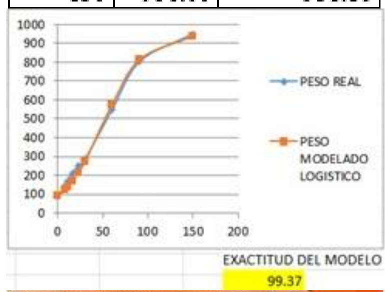


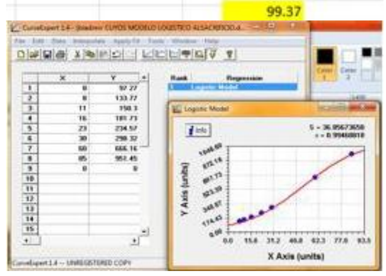
And as a last step, the factor K or earliness of growth (slope) is adjusted from K=6.19 to K =9.45, observe the adjustment that originates and its corresponding coefficient of determination that yields.

Factores	
A	950
K	9.45
B	0.0445

With this approximation, the model is adjusted and these model factors are checked with the curve expert 1.4 software, obtaining the following results:

EDAD	PESO REAL	PESO MODELADO LOGISTICO
0	88.27	90.91
8	143.08	124.68
11	169.97	139.87
16	210.77	168.54
23	250.77	216.12
30	285.38	272.45
60	546.80	574.21
91	805	815.64
150	950.00	938.80





A correlation coefficient of 0.9946 and a standard error of 36.85 are obtained, indicating that the calculations are valid and with an excellent level of accuracy.

We now proceed to apply an analysis of variance between groups of data: real and model data, to determine if there are differences or if they are statistically equal with a percentage of alpha at 5%; this one-way ANOVA test is performed with the Minitab 16 statistical package, which yields the following results: (P>0.5) finding no differences between the two models.

Minitab run results

One-way ANOVA: ACTUAL WEIGHT, LOGISTICS MODELED WEIGHT

Source GL SC MC F P
Factor 1 223 223 0.00 0.962
Error 14 1301056 92933
Total 15 1301279

S= 304.8 R-cuad.= 0.02%
R-cuad.(adjusted) = 0.00%

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Level	N	Media	Dsv.Est.
ACTUAL WEIGHT	8	346.7	303.7
WEIGHT M LOG.	8	339.2	306.0

Individual 95% CIs for the mean based on pooled standard deviation.

Grouping information using Tukey's method:

	N	Media	Grouping
PESO REAL	8	346.7	A
PESO M LOG.	8	339.2	A

Means that do not share a letter are significantly different.

Clustering data using Tukey's method

	N	Media	Grouping
PESO REAL	8	346.7	A
PESO M LOG.	8	339.2	A

Means that do not share a letter are significantly different.

Results

An average birth weight of Andean breed guinea pigs was 88.27 g and at 150 days of age 950 g. These data are in agreement with studies that report an average birth weight of 86.7±21.6 g and a live weight for 5-month-old non-fasting males of 955±106 g (Xicohtencatl et al., 2013). Improved guinea pigs reach at 4 months of age, the weight between 1.2 to 1.5 kg can exceed these values with a higher degree of genetic improvement (Solari, 2010).

A growth curve was typified for Andean breed guinea pigs, adapted to the study region with a pre-established diet; no statistical differences were found between the logistic model and the real data. This model can reliably predict weight gain throughout the life of the guinea pig in production, the model formula would be:

Typified logistic model formula:

$$y = \frac{950}{(1+9.45*e^{(-0.0445*x)})}$$

Where the independent variable "x" will be the guinea pig days of life, the dependent variable "y" will capture the guinea pig weight for "x" days of life, this model is 99.37 accurate with respect to the real growth pattern behavior. Validated with statistical test without finding significant differences with an alpha = 0.05 obtaining a p-value = 0.962.

This model could answer several questions such as:

What is the guinea pig's birth weight?

What is the weaning weight?

What is the guinea pig's weight at 60 days?

After how many days will your weight be 500 grams?

What is the guinea pig's weight gain between 30 and 60 days? Etc.

Conclusion

A growth curve for Andean breed guinea pigs, adapted to the study region with a pre-established diet, was typified; no statistical differences were found between the logistic model and the real data. This model can reliably predict weight gain throughout the life of the guinea pig in production.

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