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Comparisons Of Some Nonlinear Functions To Describe Quail Growth Curves Of Half Diallel Cross Progeny

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Abstract

This study was conducted to investigate the effect of diallel cross among three quail varieties: Black (B), Brown (N) and White (W) on growth curves using non-linear regression models (Quadratic, cubic, logarithmic and logistics), the quail progeny fed using growth ration (24.11% crude protein and 2775 kcal metabolic energy from hatching until 14 weeks of age. The results indicated that the quadratic and cubic non-linear regression models gave best prediction to body weight for unsexed birds during rearing period 1-6 weeks in pure crosses, based on goodness of-fit criteria including high adjusted R^2, R^2 and lower Akaike information criteria. There are no-significant differences between observed and predicted body weight using prediction equation of quadratic and cubic models.

Key words: Quail, Growth Curves, diallel cross, Quadratic, Cubic, Logistic, Logarithmic.

Introduction

Many studies indicated the possibility of using diallel cross to improve the productive performance of the hybrids and create superior new genotypes or hybrids by crossing pure breeds or lines (Saadey et al., 2008; Lalev et al., 2014; Hassan and Hussain, 2017; Hassan and Ali, 2017). On the other hand, few studies focused on genetic parameters of feeding efficiency, growth curves, and meat quality characteristics of quail (Narinc et al., 2010; Narinc et al., 2013). Several previous studies conducted on growth rate of Japanese quail (Telekan et al., 2017; Faraji-Arough et al., 2018; Hassan and Ali, 2018). Growth curves are the most appropriate models for describing growth patterns and can be used to predict growth rate and to estimate body weight or body part changes over rearing period and provides an opportunity for practical explanations about decision-making (Akbas and Oguz, 1998; Yang, 2006; Vitezica, 2010). and estimating the daily nutritional requirements for growth, and calculating the total feed consumed (Ahmadi and Mottaghitalab, 2007). Standard nonlinear regression models are frequently used to describe the growth patterns (Narinç et al., 2009), and the study of growth curve in poultry, can be explain the dynamics of growth phases and measuring the feed requirements in breeding programs to improve selection and predicting body weight at different ages using the prediction equation (Yang et al., 2004). The research on the nonlinear regression of the growth process can explain the relationship between body weight and food requirements, which plays an important role in animal breeding and behavior (Sengül and Kiraz, 2005). The aim of present study was to describe the growth curve of pure crosses in the half diallel cross of quail varieties (white, black and brown plumage color) according to some standard non-linear model regression.

Materials and Methods

Birds and Evaluation

The study was conducted at Department of Animal Production, College of Agriculture, University of Diyala, Iraq, the experimental birds consist of 30 males and 60 females for each line of quail: Black (B), Brown (N) and White (W), and including three crosses of W×W, B×B and N×N, and the eggs collected during three days period and entered incubator to avoid decline in hatchability (Hassan and Abd Alsatter, 2015).

The body weights of all first generation progeny were measured weekly, from hatching up to of 14 week of age, these crosses were housed in cages (40×80×125cm) during the experimental period.

Statistical analysis

The study applied four standard models for nonlinear regression (Quadratic, Cubic, Logarithmic and Logistic), using mathematical formulas included in the statistical program SPSS Version 26 (SPSS, 2020) were adopted, which are:

Nonlinear Regression Models

1- **Quadratic Nonlinear Regression Model**

The forecast equation was calculated according to the following model

$Y=b0+b1x+b2x^2$

Y: prediction of dependent variable according to the prediction equation. b0: The intercept refers to variable Y when X=0. b1: The regression factor refers to change in the value of y as a result of the change in variable X. b2: The regression factor of squared independent variable X. X: The independent variable. X^2: square of the value of the independent variable.

2- **Nonlinear Cubic Regression Model**

$Y=b0+ (b1*x) + (b2*x^2) + (b3*x^3)$

Y: prediction of dependent variable according to the prediction equation. b0: The intercept refers to variable Y when X=0. b1: The regression factor refers to change in the value of y as a result of the change in variable X. b2: The regression factor of squared independent variable X. b3: The regression factor of cubic independent variable X. X: The independent variable. X^2: square of the independent variable. X^3: The cube of the independent variable.

3- **Logarithmic Nonlinear Regression Model**

$Y=b0+ (b1*\ln (x))$

Y: prediction of dependent variable according to the prediction equation. In: natural logarithm. b0: The intercept refers to variable Y when X=0. b1: The regression factor refers to change in the value of y as a result of the change in variable X. X: The independent variable.

4- Logistic Nonlinear regression model

Y=ln(b0)+(ln(b1)x)

Y: prediction of dependent variable according to the prediction equation. In: natural logarithm. b0: The intercept refers to variable Y when X=0. b1: The regression factor refers to change in the value of y as a result of the change in variable X. X: The independent variable.

Comparing the efficiency of nonlinear regression models

Several criteria were used to compare the efficiency of standard models in predicting different growth curves, including:

1- **Coefficient of Determination**

$$R^2=\frac{SSreg.}{SSTotal}$$

R^2: Coefficient of determination. SSreg: Sum of squares in regression analysis. SSTotal: Total sum of squares in regression analysis.

2- **Adjusted R-squared**

$$\text{Adjusted } R^2 = \frac{(1-R2)(N-1)}{N-P-1}$$

R^2_{Adju}: Adjusted R-squared. N: Sample size. R^2: Coefficient of determination. P: Number of regression parameters.

3- **Akiaki Information criterion(AIC)**

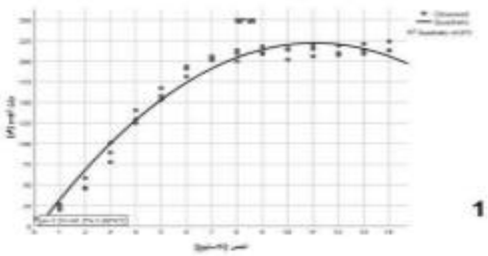
AIC=n*ln (SSe)+ 2(P+1)-n*ln(n)

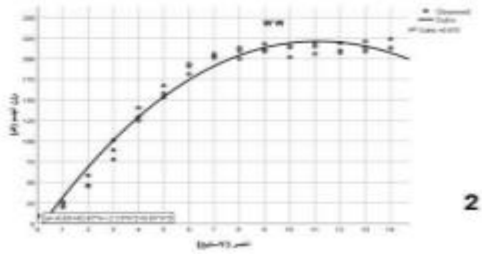
AIC: Akiaki criterion. n: sample size. P: Number of regression parameters. SSe: Sum of squares of experimental error.

Prediction accuracy of nonlinear regression models. The significance test included estimating the interval confidence limits for population mean at 0.95 confidence level and testing the predicted mean according to regression equation, if the predicted mean within the confidence limits, which indicates that there are no significant differences between the observed mean and the predicted mean, and verse versa (Al-Rawi, 1980).

Results and Discussion

The Figure 1 represent the growth curves of white variety quail from hatching age up to 14 weeks according to standard nonlinear regression models. quadratic and cubic models showed high coefficient of determination which estimated 0.975 for each model. As well as the value of the adjusted coefficient of determination ($R^2{}_{.adj}$) for quadratic and cubic models was 0.974 for each model. While the coefficient of determination for the logarithmic and logistic models was 0.933 and 0.637 respectively, as well as the value of the adjusted coefficient of determination for the logarithmic and logistic models was 0.932 and 0.629 respectively. The accuracy of prediction using the models also calculated by Akaki Information Standards (AIC), which recorded higher Akaki value quadratic and cubic models, hence recorded 228.60 and 230.42, respectively, while the Akaki value was 256.23 for logarithmic model. The logistic model was the least accurate as shown in Tables 1, 2, 3 and 4.





Nonlinear regression curve according

Nonlinear regression curve according to the cubic mode

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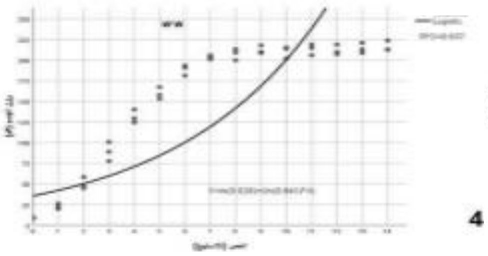

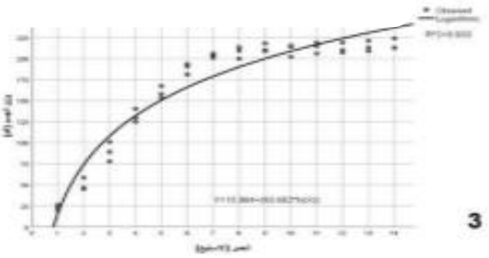

Nonlinear regression curve according

Nonlinear regression curve according to the logistics model.

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Fig1. Growth curves for white variety of quail according to standard nonlinear regression models for the period from hatching age to 14 weeks.

The Figure 2 represents growth curves of black variety of quail from hatching up to 14 weeks of age, which appeared that quadratic and cubic models are the high accurate to predict for body weight of unsexed birds in pure black variety. The adjusted coefficient of determination ($R^2_{.adj}$) recorded 0.975 in both quadratic and cubic models.

Table 1. Prediction equations for body weight in progeny from Diallel Cross using quadratic model.

Sire	Dam	Expectation equation	R^2	R^2_{Adju}	AIC
W	W	$Y = 7.51 + (41.5 * x) - (1.88 * x^2)$	0.975	0.974	228.60
B	B	$Y = 4.1 + (41.64 * x) - (1.91 * x^2)$	0.976	0.975	224.84
N	N	$Y = 5.91 + (41.63 * x) - (1.92 * x^2)$	0.973	0.972	229.93

$Y = b0 + (b1 * x) + (b2 * x^2)$

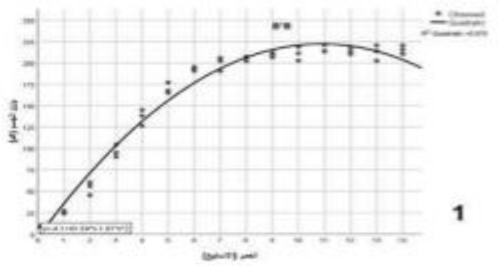
Table 2. Prediction equations for body weight in progeny from Diallel Cross using Cubic model.

Sire	Dam	Expectation equation	R^2	R^2_{Adju}	AIC
W	W	Y=8.83+(42.87*x)+(-2.13*x2)+(0.01*x3)	0.975	0.974	230.42
B	B	Y=8.54+(46.26*x)+(-2.77*x2)+(0.04*x3)	0.978	0.975	224.48
N	N	Y=8.64+(44.46*x)+(-2.44*x2)+(0.02*x3)	0.974	0.972	231.15

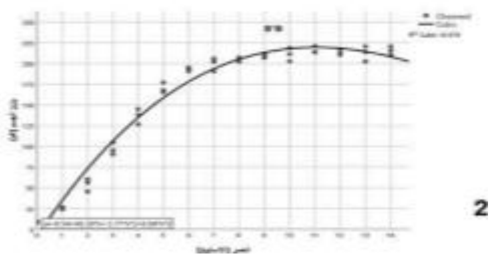
$Y = b0 + (b1*x) + (b2*x^2) + (b3*x^3)$

The prediction accuracy of models also calculated using Akaki Information Standards (AIC) which recorded 224.84 and 224.48 for quadratic and cubic models respectively, in other hand AIC recorded lower accuracy for logarithmic model compared to the quadratic and cubic models. The estimation of R^2 and $R^2{}_{\cdot adj}$ for quadratic and cubic models was 0.934 and 0.932 respectively, while the estimation of AIC for logarithmic model recorded 253.19, while the logistic model was the least accurate in prediction among models, hence the estimated R^2 and $R^2{}_{\cdot adj}$ recorded 0.616 and 0.607 respectively, as shown in Table 1, 2, 3 and 4.

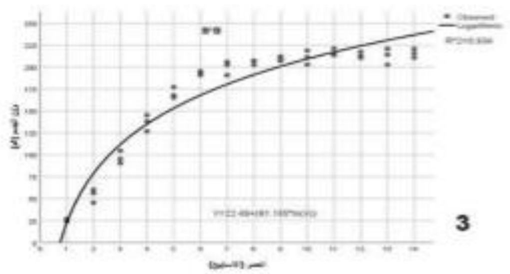
The Figure 3 represents growth curves of unsexed brown variety quail from hatching to 14 weeks of age showed that quadratic and cubic models have high prediction accurate for body weight of pure brown variety.



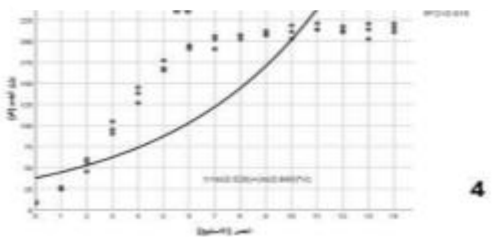
Nonlinear regression curve according to the quadratic model



Nonlinear regression curve according to the cubic model.



Nonlinear regression curve according to the Logarithmic model



Nonlinear regression curve according to the logistics model

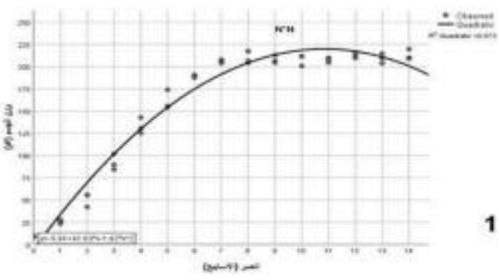
Fig 2. Growth curves of black variety quail according to standard nonlinear regression models for the period from hatching to 14 weeks of age.

Table 3. Prediction equations for body weight in progeny from Diallel Cross using Logarithmic model.

Sire	Dam	Expectation equation	R^2	R^2_{Adju}	AIC
W	W	Y = 15.98 + (83.68 * ln(x))	0.933	0.932	256.23
B	B	Y = 22.49 + (81.16 * ln(x))	0.934	0.932	253.19
N	N	Y = 20.37 + (80.95 * ln(x))	0.923	0.921	260.21

Y = b0 + (b1 * ln(x))

as The coefficient of determination of quadratic model recorded 0.973 and cubic model 0.974 as well as the estimation of adjusted determination ($R^2_{.adj}$) recorded 0.972 in both quadratic and cubic models. The AIC of quadratic and cubic models recorded 229.93 and 231.15, respectively, while the logarithmic model was low accuracy compared quadratic and cubic models.



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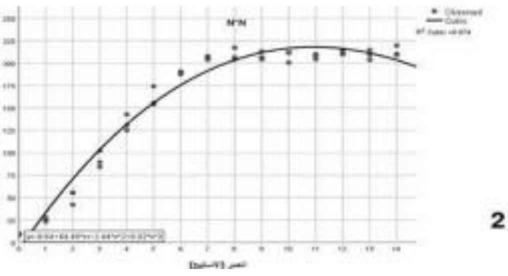

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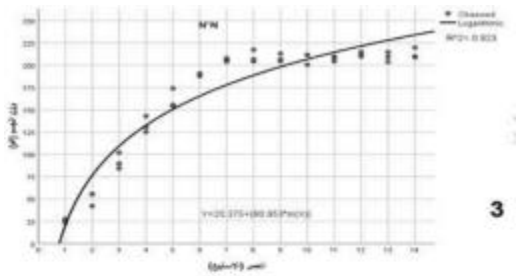
Nonlinear regression curve according to the cubic model.



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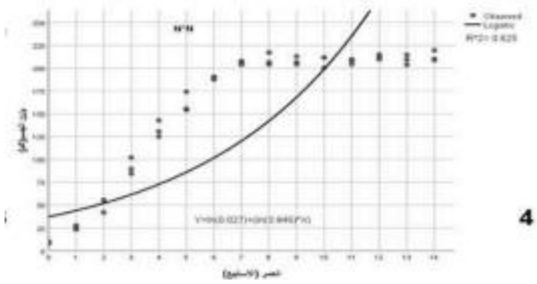
Nonlinear regression curve according to the Logarithmic model



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Nonlinear regression curve according to the logistics model.

Fig 3. Growth curves for brown variety of quail according to standard nonlinear regression models for the period from hatching age to 14 weeks.

The estimation of R^2 and $R^2_{.adj}$ is 0.923 and 0.921 respectively, while the AIC is 260.21 in logarithmic model. The logistic model represent the least accurate model among others hence the estimation of R^2 and $R^2_{.adj}$ for logistic model were 0.625 and 0.617 respectively.

Table 4. Prediction equations for body weight in progeny from Diallel Cross using Logistic model.

Sire	Dam	Expectation equation	R^2	R^2_{Adju}
W	W	Y= ln (0.02) + (ln(0.84) * x)	0.637	0.629
B	B	Y= ln (0.02) + (ln(0.84) * x)	0.616	0.607
N	N	Y= ln (0.02) + (ln(0.84) * x)	0.625	0.617

Y= ln (b0) + (ln(b1) * x)

generally high R^2 of cubic and quadratic models in all crosses indicates that cubic and quadratic models is the most suitable growth function to describe the growth curve in quail for unsexed birds. The results agreed with Morais et al. (2015) who indicated that the quadratic model is the most accurate predictor of body weight in chickens during 77 days of age when comparing five breeds of broilers. The results agreed with Yavuz et al. (2019) who indicated that the cubic model is the most accurate for predicting live body weight, as $R^2_{.adj}$

was 0.986 for females and 0.997 for males to determine the appropriateness of individual growth curves for Japanese quail. The results did not agree with Gurcan et al. (2012) hence they reported that logistic model is more accurate for predicting body weight in quail, and they recorded R^2, $R^2._{adj}$ and AIC for the logistic model 0.98, 0.97 and 20.49 respectively, during 56 days of age when studying the relationship between weight Body and age by nonlinear models in Japanese quail. The results did not agree with Rezvannejad et al. (2013) as they indicated that logistic model is the most accurate for predicting body weight during 4 weeks of age for quail in comparison among three growth curves (logistic, Gompertz and Richard).

Conclusion

The conclusion of recent study focus on the success of quadratic and cubic models in prediction of body weight for pure quail varieties and appeared more accuracy compared with nonlinear growth curves of the logarithmic and logistic model.

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