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MODELING EGG CURVES IN PARTRIDGES

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Abstract: In this study, a modeling study was carried out on the weekly average values of henna partridge egg production. For this purpose, weekly average of henna partridge egg yields of 148 days from the herd consisting of 320 breeders were taken and cubic spline, Gompertz, Logistic, Richard, Schunute, Quadratic Spline, McNally and Gamma equations were used in the modeling. In the comparison of the goodness of fit of the equations, Determination Coefficient(R^2), Mean Square Error (MSE), Durbin-Watson (DW) and Akaike Information Criteria (AIC) values were taken into account. As a result of the study, Logistic (MSE= 12.4, R^2= 0.994, AIC= 43.56, DW= 2.09), Cubic Spline (MSE= 10.56, R^2= 0.996, AIC= 46.55, DW= 1.95) and McNally (MSE= 11.02, R^2= 0.996, AIC= 48.67, DW= 2.11) models were found to have the best results with similar results. It was concluded that the Schnute (MSE= 11.24, R^2= 0.990, AIC= 136.51, DW= 0.49), Gamma (MSE= 24.67, R^2= 0.991, AIC= 69.89, DW= 2.95) and Quadratic Spline (MSE= 10.43, R^2= 0.946, AIC= 149.34, DW= 2.97) models had the worst results.

Keywords: Partridge, Egg production, Curve modeling

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1. Introduction

Henna partridges are extremely important both in terms of economy and in terms of controlling harmful species due to the fact that they are materials for hunting tourism and the pests (mainly ticks) they consume in nature. Partridges produced in the partridge production centers of the Ministry of Agriculture and Forestry are released both to nature and to private hunting grounds. For this reason, it is extremely important to obtain quality eggs in terms of maximum and incubation yield in one season. This will be possible by establishing breeding flocks that are superior in terms of egg production.

As in laying hens, turkeys and Japanese quails, egg production in partridges is a complex cycle influenced by genotype and environmental factors. The effects of race, season, and age, hatching conditions, moult, feeding style and other environmental factors on egg production in poultry are too high to be ignored. Although these factors are different from population to population, the curve they will form will show a similar distribution. The main purpose of modeling egg yield curves is to estimate the egg yield of the flock in the early stages, and to use it for selection and creation of breeding flocks. The aim is to create a flock with maximum productivity in terms of egg production. Of course, in the selection to be made on the basis of these models, the decision-making and process will be shortened. As a result, the degree of accuracy in selection will also increase. In particular, the approach of modeling individual egg production will increase the probability of selecting individuals with high genetic capacity on a flock basis. However, it is not considered possible in this application, especially in henna partridge. Because in practice the ratio of male to female is usually 1:4 (1 male: 4 females) and it is difficult to determine the individual eggs of females kept in the same compartment. As the number of females per male increases, the fertility rate decreases (Alkan et al., 2008). On the other hand, the ratio of 1:1 is not preferred as it will cause the necessity of feeding more male individuals. For this reason, egg curves are mostly obtained and modeled over cage or flock averages.

2. Materials and Methods

2.1. Materials

In this study, 148 days (December 17-13 May) henna partridge egg yields were obtained from the Kapıçam Henna Partridge Production Center, which is affiliated to the Republic of Türkiye Ministry of Agriculture and Forestry, Kahramanmaraş Nature Conservation and National Parks Branch Office. Daily egg numbers of 320 breeders in 2021 were obtained and a modeling study was carried out on the weekly average values of egg yields corresponding to 20 weeks.

2.2. Methods

In this study, segmented Cubic Spline (two-knotted), Gompertz, Logistic, Richard, Schunute, Quadratic Spline, McNally and Gamma models were used to model the egg production of henna partridges. The curve and model parameter estimations of egg yields were made in the SAS package program (SAS, 2011).

Equations of these models and their expansions are as follows (Equations 1-8);

Cubic Spline:

$$w_t = \beta_0 + \beta_1 t + \beta_2 t^2 + \beta_3 t^3 + \beta_4 (t-\alpha)^3 + \beta_5 (t-b)^3 \quad (1)$$

Logistic:

$$w_t = \beta_0/(1+\beta_1 e(-\beta_2 \quad (2)$$

Gompertz:

$$w_t = \beta_0 e(-\beta_2 e(-\beta_3 t) \quad (3)$$

Richard:

$$w_t = 1/(\beta_0 + \beta_1 e(\beta_2 t)^{(-\beta_3)} \quad (4)$$

Schunute:

$$Z_1 = \beta_4{}^{(\beta_2)} - \beta_3{}^{(\beta_2)}, Z_2 = \beta_3{}^{(\beta_2 + Z_1)},$$
$$Z_3 = (1 - e(-\beta_1 (X - X_1)/(1 - e(-\beta_1 (X_2 - X_1))^{(\frac{1}{\beta_2})} \quad (5)$$
$$w_t = Z_1 Z_3$$

Quadratic spline:

$$w_t = \beta_0 + \beta_1 t + \beta_2 t^2 \quad (6)$$

McNally:

$$w_t = \beta_0 t^{(\beta_1)} e(-\beta_2 t + \beta_3 t^{0.5} \quad (7)$$

Gamma:

$$w_t = \beta_0 t^{(\beta_1)} e(-\beta_2 t) \quad (8)$$

here w_t: t. number of eggs per week β_0, β_1, β_2, β_3, β_4 ve β_5 constants defined for models, a and b; in the piecewise regression, the nodal points, e: 2.7182, t: represent the week (Yavuz et al., 2019; Mazi, 2021).

Determination Coefficient, Mean Error Squares, Durbin-Watson and AIC (Akaike Information Criteria) were taken into account in the comparison of the goodness of fit of the equations used in the modeling (Narinç et al., 2014; Şengül et al., 2016; Kazancı, 2019). The average of the obtained values of egg production on a weekly basis was taken and modeling was done on the average values of 20 weeks.

3. Results

In this study, in which the egg production curves of henna partridges were modeled, it was concluded that the Logistic, Cubic Spline and McNally models were similar and gave the best values in terms of comparison criteria. It was determined that Schnute, Gamma and Quadratic Spline models had the worst results in terms of goodness of fit. In the literature, it is seen that different models are applied in the modeling of egg yield curves in layer hens, quails and henna partridges. Considering that many environmental factors affect egg production such as breed, age, temperature, humidity, feeding style, etc., although there are small changes in the standard egg yield curve in each egg production period, it is necessary to give priority to the models obtained from this and similar studies and to have more than one model in the modeling. The use of a model is extremely important in terms of breeding. On the other hand, it must be taken into account that the determined model can be interpreted as biologically meaningful.

The arithmetic mean, standard deviation, maximum and minimum values for 20-week-old egg yields are given in Table 1. As a result of the study, the Coefficient of Determination, Mean Error Squares, Durbin-Watson and AIC (Akaike Information Criteria) used in the comparison of the model fit of the equations used in the modeling of the egg production curve are given in Table 2. In Figure 1, the point distribution of egg yields of 320 breeder henna partridges at 148 days, and in Figure 2, the curves created for 20-week egg yields are given.

Table 1. Descriptive statistics of egg yield values

Week	Number of eggs			
	$\bar{X}$	S	Mak	Min
1	15.762	6.934	8	26
2	27.042	1.676	29	21
3	26.619	1.471	20	31
4	26.952	2.344	19	33
5	29.905	2.884	26	35
6	44.233	3.244	39	52
7	50.952	1.595	43	57
8	54.857	1.986	49	29
9	56.095	0.474	51	19
10	61.762	3.372	59	71
11	54.143	2.181	51	69
12	51.667	1.113	47	61
13	52.048	1.844	49	65

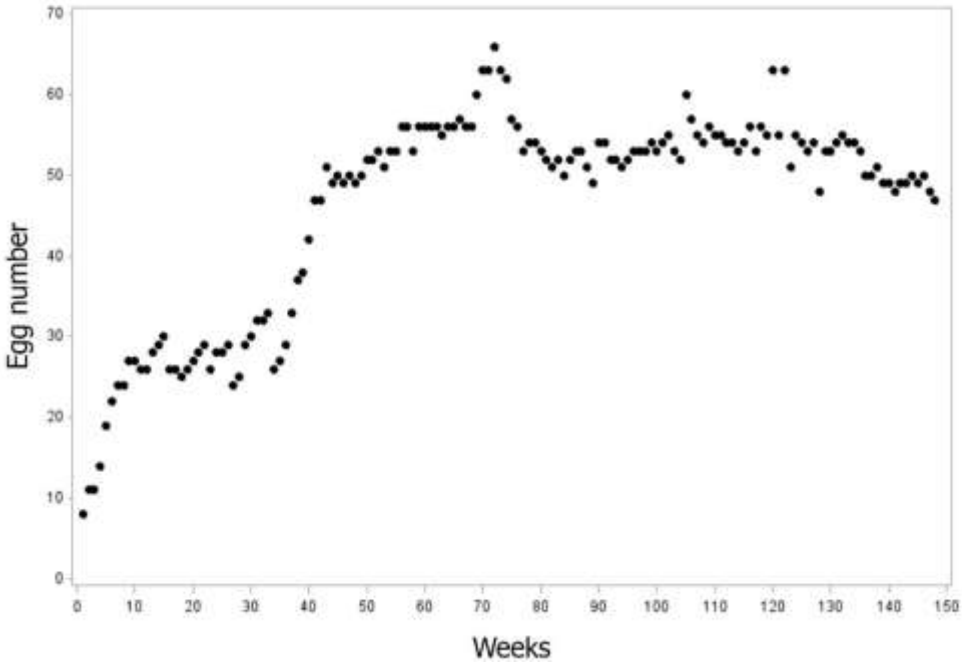

Figure 1. Point distribution of egg yields for 320 breeding henna partridges for 148 days.

Table 2. Mean Error Squares, Coefficient of Determination, Akaike Information Criteria and Durbin-Watson autocorrelation values of egg yield curves

Model	HKO	R^2	AIC	DW
Richard	16.1	0.994	89.71	2.99
Logistic	12.4	0.995	43.56	2.09
Gompertz	13.9	0.994	71.52	2.13
Schnute	11.24	0.990	136.51	0.49
Cubic Spline	10.56	0.996	46.55	1.95
Quadratic Spline	10.43	0.946	149.34	2.97
McNally	11.02	0.996	48.67	2.11
Gamma	24.67	0.991	169.89	2.95

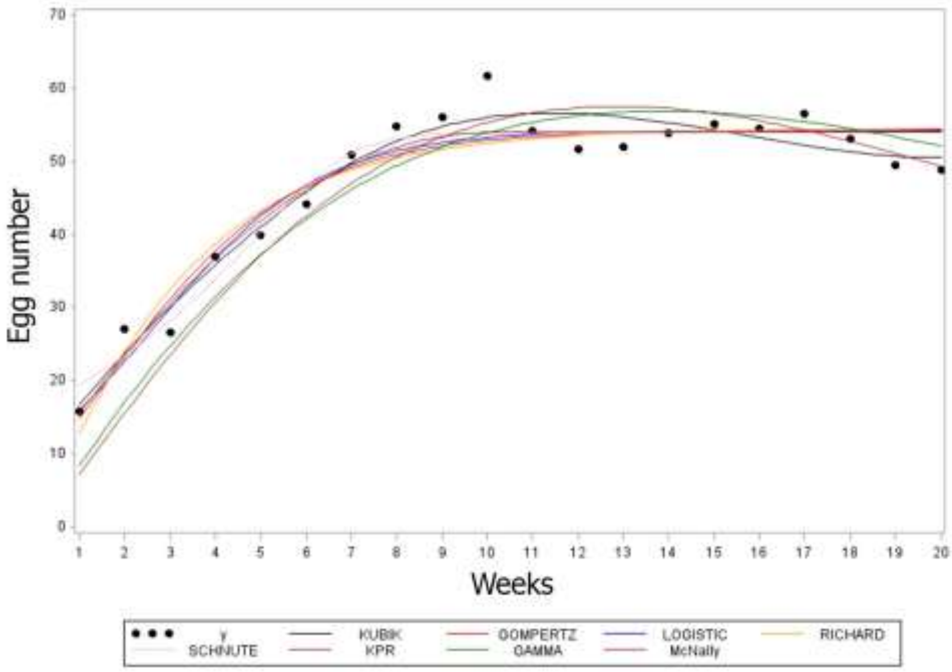

Figure 2. Curves created for 20-week egg yields.

4. Discussion and Conclusion

When the Mean Error Squares, Coefficient of Determination, Akaike Information Criteria and Durbin-Watson Autocorrelation values of the egg yield curves in Table 2 are examined, it is seen that the Logistic, Cubic Spline and McNally models give similar results. All three models have the best results compared to other models. It is seen that Schnute, Gamma and Quadratic Spline models have the worst results. It is seen that especially the AIC values of these three models are quite high compared to the other models, and the DW values are quite close to the negative or positive autocorrelation limit values. When the curves created for all models in Figure 2 are examined, it supports the findings obtained.

Şengül et al. (2016), non-linear Gamma, McNally, Modified Compartmental and Adams-Bell models were used to model egg production in henna partridges and it was concluded that McNally model is the best model to describe egg production in partridges, while AdamsBell model obtained the least descriptive model. Yalçınöz and Şahin (2020), two different Cubic Piecewise Regression (two and three node), Logistics, MMF, Gamma, McNally, Modified Compartmental and Quadratic Piecewise Regression models used in modeling egg production curves in layer hens, and the best results are from the Modified Compartmental model. They reported that Cubic Piecewise Regression (two and three nodes), Logistics, MMF and McNally models gave very close values to the Modified Compartmental model in terms of model comparison criteria.

Thuja (2021) used Cubic, Gompertz, Logistics, Gamma, Richard, Schunute, Quadratic Spline and McNeally equations to model the average egg yield curves in Japanese quails and reported that the best results in average egg yield were obtained from the Bifid Cubic Piecewise Regression model. The results obtained from this study Sengul et al. (2016), Yalçınöz and Şahin (2020), Üçkardeş and Narinç (2014) and Mazı (2021).

Author Contributions

The percentage of the author(s) contributions is present below. All authors reviewed and approved final version of the manuscript.

	T.T.	E.Y.	M.Ş.	İ.G.
C	25	25	25	25
D	25	25	25	25
S	25	25	25	25
DCP	25	25	25	25
DAI	25	25	25	25
L	25	25	25	25
W	25	25	25	25
CR	25	25	25	25
SR	25	25	25	25
PM	25	25	25	25
FA	-	-	-	-

C=Concept, D= design, S= supervision, DCP= data collection and/or processing, DAI= data analysis and/or interpretation, L= literature search, W= writing, CR= critical review, SR= submission and revision, PM= project management, FA= funding acquisition.

Conflict of Interest

The authors declared that there is no conflict of interest.

Ethical Consideration

Ethics committee approval was not required for this study because of there was no study on animals or humans. The data taken from Kapiçam Henna Partridge Production Center, which is affiliated to the Republic of Türkiye Ministry of Agriculture and Forestry, Kahramanmaraş Nature Conservation and National Parks Branch Office. There was no applied study on animals.

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