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STUDY ON MATHEMATICAL MODELS OF EGG PRODUCTION CURVE IN JINYUN DUCKS

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Abstract

In this paper, the laying rate of 72-week-old Jinyun ducks was fitted using Lorentz model, Polynomial model, Boltzmann model and Wood model, which gave R2 values as 0.63386, 0.96883, 0.91554 and 0.7240, respectively. This result revealed that Polynomial model is found to be the best to fit egg production curve in Jinyun ducks amongst these four mathematical models.

0. Introduction

Mathematical model of egg production curve was used to research and recognize the pattern of egg production rate accompanying time from the dynamic prospective. The advantage of this model is that parvus diameters can reflect changing characteristics of the whole egg laying process and then intra and vivo factors of change of egg laying will be further analyzed by approaching these parameters, which has implication for hereditary breeding, raising management and manufactural system

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analysis. Reports about Mathematical model of egg production curve of poultry were available [1-8].

In this paper, four mathematical models named Lorentz model, Polynomial model, Boltzmann model and Wood model were employed to fit laying rate materials of 72-week-old Jinyun ducks, the scope of which is to compare the fitting effects of these models against egg production curve of Jinyun ducks.

1. Materials and Methods

1.1. Materials

The number of eggs that Jinyun ducks laid was from the laying eggs record in stock field (Jinyun county of Zhejiang province) of Jinyun ducks in 2003.

1.2. Statistical analysis method

The laying rate is expressed by using the laying eggs of each day to divide the whole number of ducks. The average of successive laying rate of 7 days was acted as laying rate of per-week tested ducks. Jinyun ducks were added up for 58 weeks from 14th week to 72nd. During analysis, data of analysis was carried out using complete data of laying rate of each week to fit four models, respectively.

1.3. Mathematical models

Lorentz model: $y = a + \frac{2b}{\pi}\frac{c}{4(t-t_0)^2 + c^2}$,

Polynomial model: $Y = d + et + ft^2 + gt^3 + ht^4 + it^5$,

Boltzmann model: $Y = \frac{j-k}{1+e^{(t-t_0)/l}} + k$,

Wood model: $Y = mt^n e^{-pt}$,

where Y represents average egg laying rate of t-th week during egg laying period and a, b, c, d, e, f, g, h, i, j, k, l, m, n, p denote undetermined parameters and e represents the base of natural logarithm.

1.4. Analysis method for data

Data were analyzed by Origin software [1].

2. Results and Analysis

Lorentz model, Polynomial model, Boltzmann model and Wood model were used to fit egg laying materials of 72-week-old Jinyun ducks and the corresponding fitting results were shown in Figures 1-4 and Table 1.

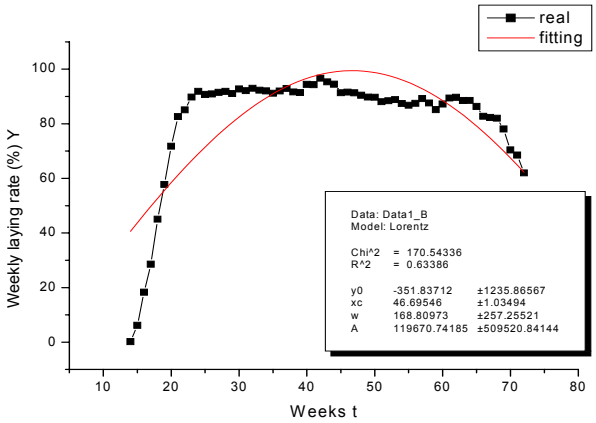

Figure 1. Egg production curves for the observed and Lorentz model in Jinyun ducks.

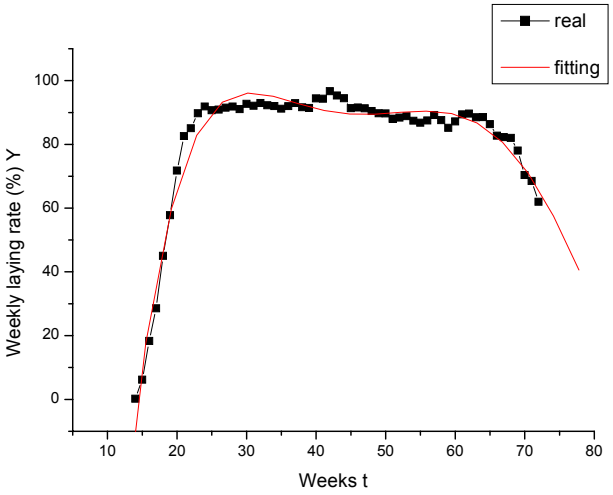

Figure 2. Egg production curves for the observed and Polynomial model in Jinyun ducks.

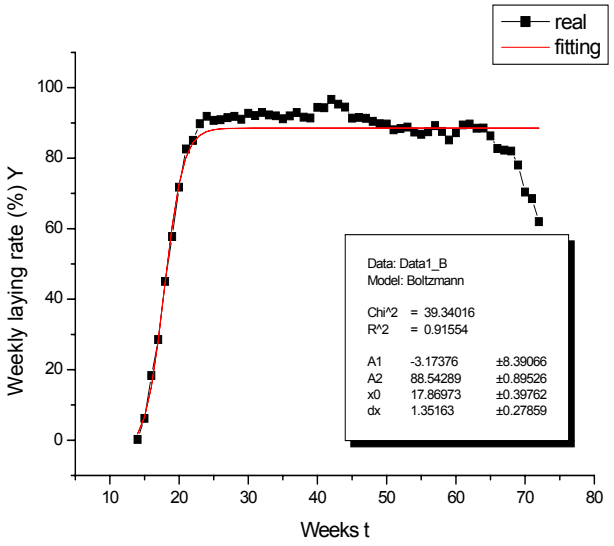

Figure 3. Egg production curves for the observed and Boltzmann model in Jinyun ducks.

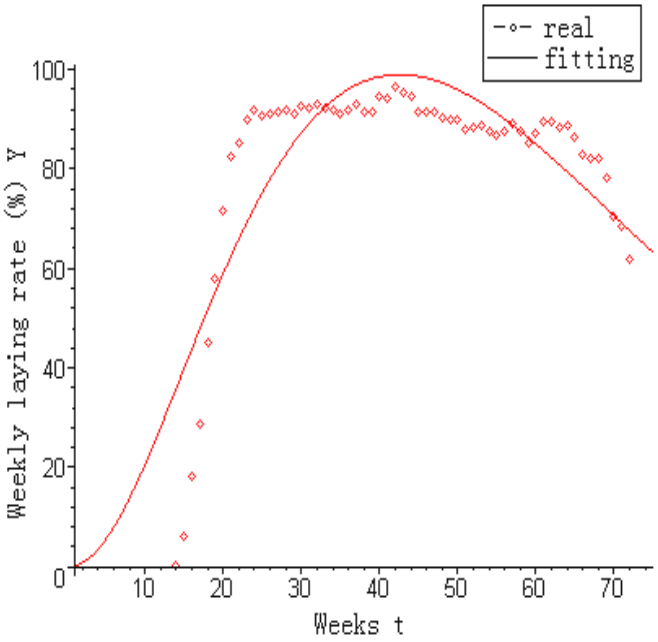

Figure 4. Egg production curves for the observed and Wood model in Jinyun ducks.

Table 1. Fitting effect of 72-week-old Jinyun ducks using mathematical models

Name of model	Time at peak (w)	Actual (w)	Egg laying at peak (%)	Actual (%)	R^2
Lorentz model	48	42	99.3	96.8	0.63386
Polynomial model	41	42	94.6	96.8	0.96883
Boltzmann model	28~72	42	88.7	96.8	0.91554
Wood model	42	42	99.5	96.8	0.7240

Four fitting models were below:

Lorentz model: $$y = -351.84 + \frac{40403235.24}{4(t - 46.70)^2 + 28496.82},$$

Polynomial model: $$y = -594.29 + 74.82t - 3.10t^2 + 0.06t^3 - 5.70 \times 10^{-4}t^4 + 2.06 \times 10^{-6}t^5,$$

Boltzmann model: $$y = 88.54 + \frac{-91.71}{1 + e^{(t-17.87)/1.35}},$$

Wood model: $$y = 0.178t^{2.298}e^{-0.054t}.$$

As shown in Figures 1-4 and Table 1, viewed from actual laying egg curve of Jinyun ducks, the laying rate increased rapidly after 14th week post laying and exceeded 80% after 8th week post laying, which approximately maintained for 48 weeks (21st week through 68th) and the laying rate reached maximum at the 42nd and the corresponding peak was 96.8%. However, time of the peak of laying rate using polynomial fitting curve was 41st week and less one week than actuality. The laying rate peak of polynomial fitting curve was 94.6% (lower 2.1% than actuality). Fitting curve maintained for 42 w (24th-65th) at peak (more than 80%) of egg laying and was identical to actual egg laying curve. The egg laying of fitting curve of Lorentz model reached the peak at 48th w earlier than 6 w and the corresponding egg laying peak was 99.3% (2.5% higher than actuality). For Boltzmann model, the egg laying of fitting

curve reached the peak at 28th w earlier than 14 w and the corresponding egg laying peak was 88.7% (8.1% lower than actuality). When Wood model was viewed, the egg laying of fitting curve reached the peak at 42nd and was consistent with actuality and the corresponding egg laying peak was 99.3% (2.5% higher than actuality) and the corresponding egg laying peak was 99.5% (2.7% higher than actuality). For Lorentz model and Wood model, the duration time of fitting curve at peak was very short. Fitting curve did not drop down any longer at egg laying peak, which lightly coincide with actual egg laying curve. Viewed from R^2 values of fitting (fitting dimension), these mathematical models were in following order: Polynomial model > Boltzmann model > Wood model > Lorentz model. Accordingly, it is reasonable that Polynomial model was the best to fit egg laying of Jinyun ducks during these four models.

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