Kafkas Univ Vet Fak Derg
19 (4): 669-672, 2013
DOI: 10.9775/kvfd.2013.8635

Journal Home-Page: http://vetdergi.kafkas.edu.tr
Online Submission: http://vetdergikafkas.org

RESEARCH ARTICLE

Comparison of Growth Curves of Broiler under Different Stocking Densities by Gompertz Model

Ahmet ŞEKEROĞLU [1] Yalçın TAHTALI [2] Musa SARICA [3]
M. Şükrü GÜLAY [4] Samet Hasan ABACI [3] Mustafa DUMAN [2]

[1] Nigde University, Faculty of Agricultural Sciences and Technologies, Department of Animal Production and Technologies, TR-51240 Nigde - TURKEY
[2] Gaziosmanpaşa University, Faculty of Agriculture, Department of Animal Science, TR-60250 Tokat - TURKEY
[3] Ondokuzmayıs University Faculty of Agriculture, Department of Animal Science, TR-55139 Samsun - TURKEY
[4] Mehmet Akif Ersoy University, Veterinary Faculty, Department of Physiology, TR-15100 Burdur - TURKEY

Makale Kodu (Article Code): KVFD-2013-8635

Summary

The knowledge of the growth curve in poultry science is very useful for describing growth kinetics and setting commercial management procedures. The objective of this research was to fit the Gompertz growth curve from hatching weights to 42 d-old weights of broilers in 3 stocking density groups. A total of 284 Ross 308 broilers randomly divided into 3 stocking density groups (9, 13 and 17 birds/m^2) in this experiment. All birds were weighted weekly. The asymptotic weight (A) of broiler chickens for 9, 13 and 17 bird/m^2 stocking density groups were 4198.46, 3807.45 and 3999.92 g, respectively (P<0.05). The growth rates (K) of broiler chickens for 9, 13 and 17 bird/m^2 stocking density groups were 0.055, 0.058 and 0.052, respectively (P<0.01). The coefficient of determination for all stocking density groups were 0.998, 0.997 and 0.996, respectively (P<0.05). Moreover, the mean square error (MSE) value was lowest for 9 bird/m^2 group (P<0.05). The current study suggested that stocking density of 9 bird/m^2 was better for the broiler growth of the different stocking densities on the base of mature live weight (A), coefficient of determination (R^2) and mean square error (MSE).

Keywords: *Growth Curves, Gompertz model, Stocking Densities, Broiler*

Farklı Yerleşim Sıklıklarındaki Etlik Piliçlerin Büyüme Eğrilerinin Gompertz Modeli İle Karşılaştırılması

Özet

Kanatlı biliminde büyüme eğrisinin bilinmesi büyümenin tarifinde ve yetiştirme tekniklerinin uygulanmasında çok önemlidir. Bu araştırmanın amacı kuluçkadan 42. gün ağırlığına kadar üç yerleşim sıklığında yetiştirilen etlik piliçlerden elde edilen canlı ağırlıkları, Gompertz büyüme eğrisi modeli ile tahmin etmektir. Denemede 3 yerleşim sıklığında (9, 13 ve 17 etlik piliç/m^2) tesadüfen dağıtılan toplam 284 adet Ross 308 etlik piliç kullanılmıştır. Bütün hayvanlar haftalık olarak tartılmıştır. 9, 13 ve 17 etlik piliç/m^2 yerleşim sıklığında etlik piliçlerin, asimptotik ağırlıkları (A) sırasıyla; 4198.46, 3807.45 ve 3999.92 g olarak (P<0.05); büyüme oranı (K) sırasıyla 0.055, 0.058 ve 0.052 olarak (P<0.01) tahmin edilmiştir. Tüm yerleşim sıklıklarında belirtme katsayısı değeri (R^2) sırasıyla 0.998, 997 ve 0.996 olarak bulunmuştur (P<0.05). Ek olarak hata kareler ortalaması (MSE) yerleşim sıklığı 9/m^2 olan grupta en düşüktür (P<0.05). Bu çalışmanın sonucunda tahmini ergin canlı ağırlığa (A), belirtme katsayısı değeri (R2) ve hata kareler ortalamasına (MSE) göre 9 etlik piliç/m^2 olan yerleşim sıklığında etlik piliçlerin büyümelerinin daha iyi olduğu söylenebilir.

Anahtar sözcükler: *Büyüme eğrisi, Gompertz model, Yerleşim sıklığı, Etlik piliç*

INTRODUCTION

Poultry industries face various decisions in the production cycle that include nutrient and mineral supply to birds, cost and type of feed, status of bird health, welfare and environmental issues that affect the profitability of operation [1]. The stocking densities in broilers vary widely by countries, husbandry systems and final body weights [2]. Although the use of high stocking densities can diminish individual growth [3-6], increase in total production meat

İletişim (Correspondence)
+90 388 2252151
ahmet.sekeroglu@nigde.edu.tr

per unit of floor surface, which results in higher profit. Thus, because of the economic benefits, producers have reluctant to decrease stocking densities [7,8].

Although there have been various definitions of growth given by different biologists, for the purposes of quantitative analysis, growth was defined as the process of an animal gaining weight with time until it reaches maturity [9]. Growth functions have been shown to be valuable tools for analyzing growth responses to genetic selection, environmental change [10] and estimation of daily nutrient requirements for growth [11]. An appropriate growth functions provide a good way of summarizing the information contained in such data into a few parameters that can be interpreted biologically and physically [11,12]. Thus, the aim of the present study was to investigate the effect of stocking density on the growth curve of broiler chickens according to Gompertz growth model.

MATERIAL and METHODS

A total of 284 chicks (Ross 308) were selected from a commercial flock. Chickens were wing-tagged at 1 d of age and individual body weights were recorded weekly at the end of each one-week period. The chicks were raised in deep litter system and were subjected to the same management, hygienic and climatic conditions. Chickens were randomly placed into the floor systems in 3 stocking density groups with 3 repetitions for each group. The three stocking densities were 9 (density 1, 66 birds), 13 (density 2, 97 birds), and 17 (density 3, 121 birds), birds per m^2 and were raised to 42 d of age. The space for density 1, density 2 and density 3 were 2.77 m^2; 2.76 m^2 and 2.82 m^2 respectively for per replicate.

Chickens were fed a 4-phase feeding program with starter fed to first 11 d (23% CP and 3.050 kcal/kg of ME), grower fed from 12 to 21 d (22% CP and 3.100 kcal/kg of ME), finisher fed from 22 to 35 d (20% CP and 3.200 kcal/kg of ME) and a withdrawal feed from 36 to 42 d (18% CP and 3.200 kcal/kg of ME). Diets were provided *ad libitum* and the birds had free access to water. Birds in all 3 groups were allocated with equal space of feeders and drinkers.

The birds were raised according to a typical commercial management program. The photoperiod was 24 h/day. Temperature started at 32.0°C and was gradually reduced 1°C degrees every day until 22.0°C was attained, after which temperature remained constant.

The widely used nonlinear growth model, Gompertz function was applied to estimate the mean age-live weight relationship [13]. The mathematical relation of this model was as follows:

$$W = A.\exp(-B.\exp^{(-Kt)})$$

Where;

(W) is the body weight (g) at age (t); (A) is the asymptotic weight or maximum growth response (g); (B) is the initial weight; (K) is the growth rate; (t) is the age in days.

Statistical Analysis

The Gompertz nonlinear regression model [14] was employed using the SAS statistical package program [15]. The results obtained with Gompertz models was evaluated in an Excel spreadsheet. Kolmogorov-Smirnov test was performed to check the assumption of normality for Gompertz models coefficients. However, the estimated coefficients were non homogeneously distributed ($P<0.05$). Therefore, the coefficient differences were determined by the Kruskal Wallis H test. Dunn's multiple comparison tests was also used to compare groups.

RESULTS

The estimated parameter values by using the Gompertz growth function for live weight of broiler chickens for different stocking densities are given in *Table 1* and growth curves in *Fig. 1*.

Stocking density significantly affected the asymptotic weight ($P<0.05$), initial weight ($P<0.01$), growth rate ($P<0.01$), determination of coefficients ($P<0.05$) and the mean square error ($P<0.01$).

DISCUSSION

In the current study, predicted asymptotic weights (A) were 4198.455, 3807.447 and 3999.922 g for stocking densities of 9 bird/m^2, 13 bird/m^2 and 17 bird/m^2,

Table 1. *Effects of stocking density on growth parameters estimated by Gompertz model*
Tablo 1. *Gompertz modelle tahmin edilen büyüme parametreleri üzerine yerleşim sıklığının etkisi*

Stocking Density (Bird/m^2)	A	B	K	R^2	MSE
9	4198.46±442.73^a	4.83±0.342^a	0.055±0.006^b	0.998^a	2110^a
13	3807.45±436.49^b	4.78±0.387^a	0.058±0.007^a	0.997^{ab}	2846^b
17	3999.92±585.65^{ab}	4.56±0.387^b	0.052±0.008^c	0.996^b	2950^b
P	<0.019	<0.001	<0.001	<0.011	<0.012

(A) The asymptotic or mature weight (g); (B) the initial weight; (K) the growth rate; (R^2) determination of coefficients; (MSE) the mean square error

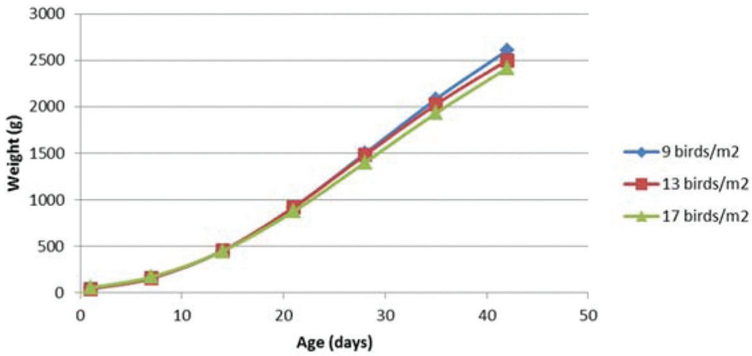

Fig 1. Estimated growth curves of Ross 308 chickens in different stocking density groups (1 to 42 d of age)

Şekil 1. Farklı yerleşim sıklığında 1-42. gün yaşa kadar Ross 308 etlik piliçlerin tahmin edilen büyüme eğrisi

respectively. Differences between stocking densities were observed in the Gompertz function parameters (P<0.05). Based on calculated A value, asymptotic weight for stocking densities is arranged in descending order as 9 bird/m^2, 17 bird/m^2 and 13 bird/m^2. Although Santos et al.[16] found similar asymptotic weight in their study (4136-4320 g). However, other studies usually reported lower asymptotic weight (Roush et al.[17], 2936 g; Mignon-Grasteau et al.[18]; 3472 g, and Norris et al.[19]; 2691-2819 g). Overall 9 bird/m^2 group had higher estimates for asymptotic weight. Lower stocking density may contribute to animal welfare, reduce stress and consequently resulted in better performance.

The estimation of the initial weight (B) was lower in the stocking density of 17 bird/m^2, while stocking density of 9 bird/m^2 showed higher values. The growth rates (K) were ranged from 0.052 to 0.058, showing the early growth rates for chicks in stocking density of 13 bird/m^2 group compared with others. Different ranges for (K) values had been previously reported. Lower values were reported by Yakupoglu and Atil [20], Mignon- Grasteau et al.[18], and Norris et al.[19]. Similar values for the growth rate K were estimated by Marcato et al.[21]. However, Santos et al.[16] and Goliomytis et al.[22] reported higher (K) values when compared with the present study. The higher estimated growth rate values (K) suggested that broiler chickens in stocking density of 13 bird/m^2 group mature earlier than other chickens. It can be expected that individuals with lower K values would reach to the asymptotic weight (A) later than individuals with higher K values [23,24].

The determination of coefficients (R^2) of stocking density groups were quite high indicating excellent fit of the data. Differences were observed for R^2 values among the various density groups. All densities have considerably high R^2 values. R^2 values were highest for birds in 9 bird/m^2 stocking density group (R^2=0.998), intermediate for birds in 13 bird/m^2 stocking density group (R^2=0.997) and lowest for birds in 17 bird/m^2 stocking density group (R^2=0.996) (P<0.05). These findings are in agreement with the previous reports [11,16,17]. Grasteau et al.[18] have calculated the R^2 values of 0.980 through Gompertz models for broilers. In the current study, the mean square error (MSE) values ranged from 2110 to 2950. The stocking density 9 bird/m2 group ranked the highest due to the lowest MSE value. The MSE values in the current study suggested the stocking density 9 bird/m^2 depict better assessment for the growth of the stocking densities. Many authors [11,16,17] found similar results using the models outlined in this study.

Body weight and growth rates are economically important features for broiler productions. The present study provides information about the effect of stocking density on some growth function parameters in broilers. In this study, the stocking density of 9 bird/m^2 seemed to be appropriate for describing the broiler growth of the stocking densities according to the asymptotic or mature weight, determination of coefficients and the mean square error values.

REFERENCES

1. Durmani Kuhi H, Porter T, López S, Kebreab E, Strathe AB, Dumas A, Dijkstra J, France J: A review of mathematical functions for the analysis of growth in poultry. *World Poultry Sci J,* 66 (2): 227-240, 2010.

2. Sarıca M, Erensayın C: Etlik piliç yetiştiriciliği. **In,** Türkoğlu M, Sarica M (Eds): Tavukçuluk Bilimi. s.239-263, Bey Ofset Matmacılık, Ankara, 2009.

3. Şekeroğlu A, Berberoğlu E, Demir E, Sarıca M: Etlik piliçlerde yerleşim sıklığının performansa ve atlık nem düzeyine etkisi. *1. Doğuanadolu Kanatlı Sempozyumu, 21-24 Mayıs, Van,* s.11-16, 2001.

4. El-Deek AA, Al-Harthi MA: Responses of modern broiler chicks to stocking density, green tea, commercial multi enzymes and their interactions on productive performance, carcass characteristics, liver composition and plasma constituents. *Int J Poult Sci,* 3 (10): 635-645, 2004.

5. Türkyılmaz MK: The effect of stocking density on stres reaction in broiler chickens during summer. *Turk J Vet Anim Sci,* 32 (1): 31-36, 2008.

6. Skomorucha I, Muchacka R, Osnówka-Czajka SE, Herbul E: Response of broiler chickens from three genetic groups to different stocking densities. *Ann Anim Sci,* 9 (2): 175-184, 2009.

7. Shanawany MM: Broiler performance under high stocking densities. *Br Poult Sci,* 29 (1): 43-52, 1988.

8. Feddes JJR, Emmanuel EJ, Zuidhoft MJ: Broiler performance, body weight variance, feed and water intake, and carcass quality at different stocking densities. *Poult sci,* 81 (6): 774-779, 2002.

9. Porter T, Kebreab E, Darmani Kuhi H, Lopez S, Strathe AB, France J: Flexible alternatives to the Gompertz equation for describing growth with age in turkey hens. *Poult Sci,* 89 (2): 371-378, 2010.

10. Goto T, Goto N, Shiraishi J, Bungo T, Tsudzuki M: Comparison of growth curves of four breed of Japanese native chicken, onaga-dori, tosa-jidori, ukokkei and hinai-dori. *J Anim Vet Adv*, 9 (9): 1362-1365, 2010.

11. Ahmadi H, Mottaghitalab M: Hyperbolastic models as a new powerful tool to describe broiler growth kinetics. *Poult Sci,* 86 (11): 2461-2465, 2007.

12. Fitzhugh HA: Analysis of growth curves and strategies for altering their shape, *J Anim Sci,* 42 (4): 1036-1051, 1976.

13. Mignon-Grasteau S, Beaumont C, Le Bihan-Duval E, Poivey JP, Rochambeau de H, Ricard FH: Genetic parameters of growth curve parameters in male and female chickens. *Br Poult Sci,* 40 (1): 44-51, 1999.

14. Rogers SR, Pesti GM, Marks HL: Comparison of three nonlinear regression models for describing broiler growth curves. *Growth,* 51 (2): 229-239,1987.

15. SAS: Version 8.01 SAS Institute Inc., Cary, NC. 1999.

16. Santos AL, Sakomura NK, Freitas ER, Fortes CMS, Carrilho ENVM: Comparison of free range broiler chiken strains raised in confined or semi-confined systems. *Braz J Poultry Sci,* 7 (2): 85-92, 2005.

17. Roush WB, Dozier WA, Branton SL: Comparision of Gompertz and neural networks models of broiler growth. *Poult Sci,* 85 (4): 794-797, 2006.

18. Mignon-Grasteau S, Piles M, Varona L, de Rochambeau H, Poivey JP, Blasco A, Beaumont C: Genetic analysis of growth curve parameters for male and female chickens resulting from selection on shape of growth curve. *J Anim Sci,* 78 (10): 2515-2524, 2000.

19. Norris D, Ngambi JW, Benyi K, Makgahlela ML, Shimelis HA, Nesamvuni EA: Analysis of growth curves of indigenous male Venda and Naked Neck chickens. *S Afr J Anim Sci,* 37 (1): 21-26, 2007.

20. Yakupoglu C, Atil H: Comparison of growth curve models on broilers growth curve 1: parameters estimation. *Online J Biol Sci,* 1 (7): 680-681, 2001.

21. Marcato SM, Sakomura NK, Kawauchi IM, Barbosa NAA, Freitas EC: Growth of body parts of two broiler chicken strains. *EPC2006 XII European Poultry Conference, 10-14 September, Verona - Italy,* http://www.cabi.org/animalscience/Uploads/File/AnimalScience/additionalFiles/WPSAVerona/10522.pdf, 2006.

22. Goliomytis M, Panopoulou E, Rogdakis E: Growth curves for body weight and major component parts, feed consumption, and mortality of male broiler chickens raised to maturity. *Poult Sci,* 82 (7): 1061-1068, 2003.

23. Taylor CS, Fitzhugh HA: Genetic relationships between mature weight and time taken to mature within a breed. *J Anim Sci,* 33 (4): 726-731, 1971.

24. Brown JE, Fitzhugh HA, Cartwright TC: A comparison of nonlinear models for describing weight age relationships in cattle. *J Anim Sci,* 42 (4): 810-818, 1976.