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IMPLEMENTATION OF GROWTH CURVES AND INTERPOLATION METHODS FOR FATTENING CONTINUATION DECISION

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Abstract

In classical breeding, animals of fattening material are picked up on the basis of a fixed fattening period or fattening weight. In this case, it can come out with unforeseen individual differences in the growth and fattening performances of the animals. If the animals which growth and fattening performance is not sufficient, continuation of the feed may lead to economic loss or while it is possible to produce higher meat, there may be a possible deprivation of utility with the early sale of these animals. In this study, it was aimed to develop a decision mechanism for continuing the feeding, if the expected live weight gain for the lambs is economical, otherwise the slaughtering should be referred. For this purpose, live weight of the lambs was taken from birth until the sixth month and then the first 4 months of live weights were extrapolated to the expected weights of the animals in the fifth month by using parameter estimation of the Gompertz growth curve and Shape-Preserving piecewise cubic interpolation (SPPCI) methods. With this method, it is aimed to establish a decision support system about whether fattening will be cut or not in the fourth. Profitability in this direction was determined by taking the difference between the estimated product price at the end of one month fattening and the fattening cost calculated over 3% dry matter consumption According to the research findings, it is determined that the mean of the deviations of the estimations made by the Gompertz growth curve method is higher than the SPPCI method but the standard deviation is lower. Taking into consideration the evaluations made using birth weight and the first 3 months of live weight, it is considered that the SPPCI method can be used to estimate the next measurement point and the Gompertz growth curve method can provide more reliable estimates for the estimation of more distant measurement points.

Keywords: Gompertz growth curve, Shape-Preserving piecewise cubic interpolation, Fattening, Economy

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1. Introduction

The world's Sheep farming meets the needs of people for meat and milk, as the other branch of sheep production that benefits from other products such as wool and skin (Erkan and Boga, 2018). Sheep constitutes 76% of the 44.312 million heads of small ruminants In Turkey In sheep breeding, lamb meat production has a great importance. In total red meat production, the share of sheep meat is 20.8%, of which 6.1% is lamb meat (TUIK, 2017).

In classical breeding, the animals of fattening material have got usually a fixed fattening period or the ending weight of fattening, unpredicted individual differences in these animals may have an impact on growth and fattening performances. Fattening performance is affected by internal and external factors in relation to the animal to be fed. These internal factors may be race, gender, age, type of birth etc., as well as external factors such as feed, climate, water, and care etc. (Sahin and Akmaz, 2002). Continuing feed in animals with insufficient fattening performance can lead to economic losses. In addition, while it is possible to achieve higher meat production, there may be possible deprivation of utility by sending these animals at early ages. There are some studies on this issue;

In a study conducted by Aksoy (1995), it was the result that would be appropriate for slaughter when it becomes 40 kg live weight starting from two or three months of age, after weaning for Morkaraman and Tuj male lambs taking into account daily live weight gain, tail fat and feed conversion rate. Altın et al., (2005), maintained the feeding until 10 weeks of age of Kıvırcık and Karya lambs weaned at approximately 77 days and determined feed consumption with weekly live weight during fattening. As a result, authors made a simple economic analysis of the feeding and reported that these two breeds gave similar results in terms of post-slaughter fattening performance. Tekel et al. (2007), examined the effects of fattening performance and carcass characteristics of Awassi male lambs on 60, 75, and 91 days of intensive fattening. As a result, it has been revealed that the prolongation of the fattening period can negatively affect the economy of fattening and mentioned that producing of fatty carcasses may reduce market demands. Demir et al., (2001), separated 3 groups, one of which was the control group, and applied the bovino somatotropin hormone at different doses. At the end of the 56-day fattening period, they made comparisons for the cost of fattening, and they came to the conclusion that these hormones were not economically viable for breeding. Çelikeloğlu and Tekerli (2004), applied four different mathematical models in order to study the environmental factors affecting the growth curves of the live weight of the 328 head of Pırlak lambs. It is reported that the best model is Brody, Bertalanffy, Gompertz and Logistic model respectively in terms of the determination coefficient. As a result; that female lambs had reached early adult live weight earlier than male lambs, therefore they reported that females can be dispatched to slaughtering earlier than males. Bytyqi et al. (2015), reviewed economic values for a combination of milk and meat production characteristics in four different sheep breeds in Kosovo. For this purpose, daily income and costs are calculated. The Wood function for the average daily milk yield and the Gombertz function for the live mass calculations of the lambs were used. In conclusion, this study showed that milk production for all sheep breeds raised in Kosovo has much more economic importance than meat production.

De Fatima Sieklicki et al. (2016), used Brody, Gompertz, Von Bertalanffy and Logistic model to describe the relationship between weight and age in their study with 42 heads of Texel male lambs. It has been reported that the high negative correlation between A and k parameters was found for all models examined for optimum nutritional management and slaughter weight. In this case, animals with high growth rates tend to have lower asymptotic weights than animals with low growth rates. However, it is stated that animals growing earlier can be slaughtered without anticipation of reaching a slightly higher slaughter weight. As a result, authors reported that the Body model gives the best result in terms of growth curve with high determination coefficient and low mean squares error. Lupi et al., (2015), applied the Brody, Verhulst, Gompertz, Von Bertalanffy and Logistic model to 129.610 individual live weight data during the period from birth to adulthood on Segureña sheep breeds. With the use of curve parameters as a selection criterion, the aim was to mathematically express the best cut-off time, information on the feeds that animals need and production forecasting. For rapidly growth animals, it has been reported that the curve can be deduced from the slope of the curve, which corresponds to the inflection point of the best cut time. They noted that this information could also allow marketing and commercial forecasting, as well as being able to plan feeds at the same time. The possibility that non-linear models can be used as early selection criterion for decision making in slaughtering, some curve parameters in breeding programs may be presented as a selection criterion in the development of important commercial features such as early development.

In this study, it was aimed to develop a decision mechanism for the continuation of feeding according to economy of expected live weight gain for the lambs, not based on the fattening time and aimed slaughtering weight.

2. Material and Method

2.1. Material

The data used in this study belongs to 38 Karayaka male lambs, taken from a commercial farm located in Bafra

province of Samsun. In the realization of the analysis, MATLAB V.7.12.0.635 software was used with license number of 161052 (Dhar et al., 2017).

2.1. Methods

Generally, a fixed fattening period or the end of fattening live weight is based for fattening studies. In this study, ad libitium feeding was performed and the live weight of were recorded monthly from birth to the sixth month and they were extrapolated with using first 4 month live weights and birth weight in order to estimate their expected weights in the fifth month. For this aim Gompertz growth curve (GGC) and Shape-Preserving piecewise cubic interpolation (SPPCI) methods were used. With these methods, it is aimed to establish a decision support system for the termination or continuation to feeding at the fourth month. Profitability in this direction was determined by taking the difference between the estimated product price at the end of one month's fattening and the fattening cost calculated over 3% dry matter consumption. Considering that an animal's live weight (LW) consumes forage (1.1% of LW) and concentrated feed (2.2% of LW), profitability can be calculated as;

A = LW(5m) – LW(4m)

Sale Price (SP) = 0.45A x Carcass price (43 TL/kg)

Hay Cost (HC) = LW(4m) x 1.1 x Hay price (0.55 TL/kg)

Feed Cost (FC) = LW(4m) x 2.2 x Feed price (1.3 TL/kg)

Total Cost (TC) = HC + FC

Profit = SP – TC.

In this equation, the 5th month LW data was calculated over the expected values for both methods and the same procedures were applied on the original data set taken on the 5th month and compared. For the calculation of operating costs, only feed costs are taken into consideration and other costs are assumed to be fixed.

The expected values for the 5th month were calculated using the Gompertz growth curve and the Shape-Preserving piecewise cubic interpolation (SPPCI) method.

2.2.1. Gompertz Growth Curve (GGC) method

One of the methods used in predicting growth curves is the Gompertz growth curve. The function of the Gompertz growth curve can be defined as in equation (1) (Önder et al., 2017).

$$a * \exp(-b * \exp(-kt)) \quad (1)$$

a: Asymptotic or predicted final mature weight

b: Scaling parameter (constant of integration)

k: Instantaneous growth rate (per time unit) parameter

t: Age at the inflection point

2.2.2. Shape - Preserving piecewise cubic interpolation (SPPCI) method

Data points x_k, k=0,...,n are interpolated using a piecewise cubic polynomial $P(x)$ with the following properties :

1. On each subinterval $x_k \leq x \leq x_{k+1}$, $P(x)$ is a cubic Hermite interpolating polynomial for the data points with specified slopes at the interpolation points.
2. $P(x)$ interpolates y, that is, $P(x_j)=y_j$, and the first derivative dP/dx is continuous. The second derivative d^2P/dx^2 is probably not continuous so jumps at the x_j are possible.
3. The cubic interpolant $P(x)$ is shape preserving i.e. the slopes at the x_j are chosen in such a way that $P(x)$ preserves the shape of the data and respects monotonicity (Yang and Huiyan, 1996).

3. Results and Discussion

Along with many factors affecting fattening performance, feed is the biggest expense in animal husbandry. The longevity of the fattening period can cause declines in feed consumption and also adversely affect the economy of feeding. It is clear that the most important factor is the relationship between cost and profitability over meat and feed prices. Profitability values used at the end of the fourth month for fattening termination decision was given in Table 1.

In Table 1, the profitability values used in the decision to terminate the feeding were compared at the end of the fourth month. According to the results, 24 lambs for MP and 21 lambs for SPPCIP were found not to be economical to continue the fattening. Hence, when the MP and SPPCIP are compared, it can be seen that the amount of economic losses to each animal changes, but the feed should be terminated at 16 of the same lambs. On the other hand, when GGCP was examined, it was seen that all lambs should be sent for slaughtering at the 4th month. In addition, when the mean and standard error of the difference between MP-SPPCIP and MP-GGCP were examined, it was determined that the mean of the deviations of the estimations made by the GGCP was higher than the SPPCI method, but the standard deviation was lower.

Taking into consideration the evaluations made using birth weight and the first 3 months of live weight, it is considered that the SPPCI method can be used to estimate the next measurement point and the Gompertz growth curve method can provide more reliable estimates for the estimation of more distant measurement points.

Finally, it is thought that these two methods used in the research will provide a different perspective for fattening studies as well as providing benefits such as

facilitating herd management and contributing to the national economy by further detailing the cost analysis. However, it is evident that the results require much more research to be implemented.

Conflict of interest

The authors declare that there is no conflict of interest.

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Table 1. Profitability values used at the end of the fourth month for fattening termination decision

Lamb no	MP	SPPCP	GGCP	MP-SPPCP	MP-GGCP
1	-10.57	1.26	-52.08	-11.83	41.51
2	4.57	-35.74	-37.01	40.32	41.58
3	0.67	-42.77	-35.68	43.44	36.35
4	-5.22	-3.84	-33.90	-1.38	28.68
5	14.09	26.36	-31.77	-12.26	45.87
6	5.60	31.19	-21.01	-25.59	26.61
7	-6.13	-53.37	-44.60	47.24	38.47
8	-3.97	2.16	-49.99	-6.13	46.02
9	7.34	-50.46	-41.87	57.80	49.21
10	-9.20	-59.20	-51.00	50.00	41.80
11	-4.61	-69.41	-48.12	64.80	43.51
12	2.52	21.29	-40.04	-18.77	42.56
13	1.31	6.83	-25.85	-5.52	27.16
14	-1.27	17.82	-41.11	-19.10	39.84
15	-8.98	2.87	-51.62	-11.85	42.65
16	1.80	27.72	-21.52	-25.92	23.32
17	-17.48	13.95	-56.86	-31.42	39.38
18	-7.76	-1.30	-51.40	-6.46	43.64
19	-8.86	-22.02	-53.07	13.16	44.21
20	-1.23	-44.50	-35.96	43.27	34.73
21	0.78	-39.21	-37.53	39.99	38.30
22	3.55	-53.92	-42.79	57.47	46.34
23	-9.01	-7.31	-34.48	-1.71	25.46
24	-13.68	17.41	-55.71	-31.09	42.03
25	5.67	0.02	-41.61	5.65	47.28
26	-7.08	4.60	-51.06	-11.68	43.98
27	-12.47	-0.47	-52.68	-12.00	40.21
28	1.87	-3.44	-42.80	5.32	44.68
29	-10.84	12.37	-49.57	-23.20	38.74
30	5.10	10.30	-26.14	-5.19	31.24
31	-2.33	-49.91	-43.32	47.57	40.99
32	-6.51	-71.14	-48.60	64.63	42.09
33	10.30	22.89	-32.26	-12.59	42.56
34	-13.00	-62.66	-52.19	49.67	39.19
35	-8.14	-12.01	-33.71	3.87	25.57
36	-5.07	-18.56	-51.68	13.49	46.61
37	-11.94	-15.48	-34.75	3.54	22.81
38	-7.04	15.83	-48.38	-22.87	41.33
			Total	354.66	1.476.51
			Average	9.33	38.86
			SD	4.97	1.18

MP= profit calculated from measured live weight data
SPPCIP= profit calculated for expected live weight using the SPPCI method
GGCP= profit calculated for expected live weight using the Gombertz growth curve method
SD= standard deviation

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