Biological growth patterns to increase livestock meat productivity

P S Kobylatsky¹, N V Shirokova¹, V A Karatunov², M I Slozhenkina³ and Tsitsige³

¹ Don State Agrarian University, 24, Krivoshykova str., 346493, Persianovsky, Rostov region. Russia, kpspersia@mail.ru
² Krasnodar State Agrarian University n.a. I.T. Trubilin, 13, Kalinina, 350044, Krasnodar, Russia
³ Volga Region Research Institute of Manufacture and Processing of Meat-and-Milk Production, Volgograd, 6, Rokossovsky Str., Volgograd, 400131, Russia

E-mail: karatunov1982@yandex.ru

Abstract. The article presents a study on steers’ biological growth patterns that are possible to be considered for increasing the meat productivity of steers. To enhance the live weight gain of Holstein steers, we used a variable feeding system that is based on the physiological characteristics of metabolism and takes into account growing periods and the nature of nutrient absorption by periods, corresponding to the S-shaped growth curve. Analyzing growth records of young cattle, he paid attention to some patterns of the live weight gain. These data showed that the live weight gain was uneven along the S-curve and subject to periodic fluctuations that were characterized by decreases and increases in growth; a period took 12 days, that is, the amplitude of the increase in growth made 12 days and then the decrease was also 12 days. We also divided the growth cycle into 2 periods, 12 days each. In the increase period, if the amount of feed was reduced by 20%, there was no decrease in average daily gain in steers, and vice versa, in the 12-day decrease period, a 20% increase in feed compensated for the low level of metabolism in the body with a stable rate of average daily gains. Therefore, similar amount of feed can help the traditional cattle breeding system increase the average daily gain by 8.5% and the carcass weight by 10.5% and reduce feed costs per 1 kg of gain by 7.1%.

1. Introduction

Along with the growth rate and duration, the periodicity is the element that characterizes the animal ontogenesis and is expressed in different forms, contributing to the final result of growth. Last century, scientists noted the periodic nature of the growth of farm animals that grew most intensively in the period after birth, and then the growth slowed down [1, 2]. There were found “dormant” points, when animals do not gain live weight in comparison with the average growth rate in a given period of time. There are periods of exponential growth when animals gain weight, exceeding the average indices in a fixed period of their life. Such step changes in the growth rate reflect large-scale physiological changes in the body of the animal. The growth is uneven and arrhythmic, increases and decreases from time to time. This growth is inherent not only to the body as a whole, but also to each organ, tissues, and cells. These processes in the animal body are explained by the so-called biological rhythms—activity of digestive and sex glands of different intensity and brain activity. The biological rhythms, important for
effective livestock breeding technologies, are underappreciated by industry experts. The live weight gain corresponds to an S-shaped curve or periodic variations; the time of a variation is 12 days. The growth periodicity is also observed in other farm animals, with periodic variations along the S-shaped curve being different, but strictly constant for each species. Gorlov I.F. et al. (2019) proved [3–9] that the constant influence of uniform factors on the animal organism, in particular, uniform feeding leads to inhibition of reflex activity and weakening of the metabolism; a rhythmic changing within an environmental factor, for example, the constant variation of feed types in the diet stimulates glycolytic and oxidative processes. Thus, there is a close relationship between the growth intensity, amount of nutrients consumed, nutrition, and method of feeding [10].

This relationship is expressed in the amount of nutrients absorbed by the body over the growth curve periods [11-15]. The amount of substances assimilated in cattle changes every 12 days, that is, the bottom of the curve indicates a decrease in assimilation; after 12 days, the peak shows an increase of growth. For example, a small decrease in feeding by 10-15% in the peak of nutrient assimilation does not allow reducing its average daily gain [16, 17]. That is, reducing the feed supply during certain periods of cattle fattening, it is possible to reduce their consumption per 1 kg of the live weight gain in comparison with the standard feeding with the rate of live weight gain being preserved [18-20]. The study of the growth patterns of cattle is important for the development of an effective resource-saving technology for fattening young cattle and increasing their meat productivity.

2. Problem statement
The periodic nature of the animal growth studied under different nutritional conditions is very important for cattle breeders. There are not enough data on this issue in the scientific literature. It is important to understand that the concept of a standard feeding scheme is nominal for growing young cattle. Feeding that is sufficient at the moment will lag behind the growing needs of the animal and will go from the “standard needs” category down to the category of “below the consumption standard”. It is not easy to establish the effect of feeding on the animal growth. To address this issue, we researched variable feeding tried on Holstein steers.

3. Research questions
The study of the variable feeding system, affecting the meat productivity of Holstein steers under fattening, set the following questions:

- Is the 24-day feeding cycle, combining two 12-day periods of alternating rates of increasing and decreasing by 20%, effective for Holstein steers from birth to 18 months of age?
- What is the feed cost reduction per 1 kg of the live weight gain?
- How much is the live weight gain of Holstein steers from birth to 18 months of age under variable feeding?

4. Purpose of the study
The purpose of our research was to study the growth, development, and cost of feed per 1 kg of gain in fattening Holstein steers according to the variable feeding system.

5. Methods
It was important to establish the effect of variable feeding on increasing the meat productivity of Holstein steers. For this purpose, we had 2 groups of Holstein steers with an age difference of ±3 days and a live weight difference of ±2 kg, 24 heads each. Steers in Group I (control) were fed with a standard diet. Their analogues in Group II (test) were under variable feeding that consisted in alternating feeding with two 12-day periods of increasing and then decreasing the ration (in feed units) by 20%; the whole cycle was 24 days [11]. It should be noted that steers cannot be fed this way until 6 months of age for objective reasons (including the milk period of feeding). During this period, steers in Groups I and II had similar feeding systems and rations.
Experimental animals were grown from birth to 18 months of age. During the growing period, we determined the live weight gain by monthly weighing and calculated the overall average daily weight gain and relative growth rate. The linear growth was determined by measuring, and the body indices were calculated. According to the feed consumption, their costs were determined per 1 kg of the live weight gain.

Over the entire fattening period, we spent the same amount of feed in both groups of Holstein steers (Table 1).

| Parameter                        | Amount |
|----------------------------------|--------|
| Whole milk, kg                   | 200    |
| Dry milk replacer, kg            | 80     |
| Corn silage, kg                  | 3254   |
| Green mass of alfalfa, kg        | 2602   |
| Alfalfa hay, kg                  | 844    |
| Barley straw, kg                 | 931    |
| Brewer’s grains, kg              | 1787   |
| Concentrates, kg: oatmeal mixture| 16     |
| Molasses feed, kg                | 85     |
| Monocalcium phosphate, kg        | 17     |
| Feed contained: feed units       | 3533   |
| digestable protein, kg           | 408    |
| exchange energy, mJ              | 37185  |

The test feeding system showed following results: animals in Group II fed with the same amount of feed had a larger live weight in comparison with their analogues of Group I. For example, they exceeded their peers by 20.9 kg (5.8%) (P>0.999) at the age of 12 months; and the difference increased even more and amounted to 43.1 kg (8.0 %) (P>0.999) at the age of 18 months.

Variable feeding enhanced the metabolism in the body and led to an increase in the average daily gain in young cattle. The steers in test Group II were superior to their peers grown according to the traditional feeding system by 129 g at the age of 18 months (15.1%) g (P>0.999) (Table 2).
Table 3. Average daily gain in Holstein steers on variable feeding.

| Age period | Group I (control) | Group II (test) |
|------------|-------------------|-----------------|
| months     | days              |                 |
| 0-6        | 179               | 806             |
| 0-12       | 360               | 863             |
| 0-15       | 450               | 876             |
| 0-18       | 540               | 872             |
| 6-12       | 181               | 920             |
| 6-15       | 271               | 922             |
| 6-18       | 361               | 905             |
| 12-15      | 90                | 927             |
| 12-18      | 180               | 890             |
| 15-18      | 90                | 853             |

The picture of the animal development, including individual parts of the body, would be incomplete based only on the weight gain data. Linear records of the height of Holstein steers complemented this picture (table 4.)

Table 4. Holstein steers’ linear indicators changed with age on variable feeding.

| Age, month | Group | Measurement of articles, sm | Index of body built, % |
|------------|-------|-----------------------------|------------------------|
|            | Group | Height at withers | Height at hips | Width of chest | Chest depth | Oblique body length | Chest girth | Width at book bones | Width of loin | Pastern girth | Length of legs | Length | Thoracic | Blockiness | Overgrowth | Boniness |
| 3          | I     | 82 | 83 | 22 | 40 | 62 | 82 | 29 | 13 | 14 | 51. | 2 | 75.6 | 55. | 134 | 101 | 17. |
|            | II    | 83 | 82 | 23 | 42 | 62 | 83 | 29 | 12 | 14 | 50. | 6 | 74.6 | 54. | 133 | 98.7 | 16. |
| 6          | I     | 11 | 11 | 29 | 46 | 12 | 13 | 15 | 28 | 15 | 58. | 1 | 109. | 63 | 109 | 104 | 13. |
|            | II    | 11 | 11 | 30 | 47 | 12 | 13 | 16 | 30 | 16 | 57. | 1 | 108. | 63 | 110 | 103 | 14. |
| 9          | I     | 3 | 7 | 34 | 48 | 13 | 15 | 32 | 18 | 16 | 57. | 1 | 117. | 70 | 115 | 103 | 14. |
|            | II    | 12 | 37 | 51 | 13 | 15 | 32 | 17 | 16 | 56. | 5 | 116. | 72 | 116 | 102 | 13. |
| 12         | I     | 11 | 12 | 42 | 57 | 14 | 16 | 35 | 19 | 18 | 50. | 4 | 125. | 73 | 112 | 105 | 15. |
|            | II    | 12 | 44 | 58 | 14 | 16 | 35 | 19 | 18 | 50. | 8 | 125. | 75 | 113 | 105 | 15. |
At the age of 18 months, the Holstein steers grown on a variable feeding system, exceeded their analogues in control group with respect to the index of blockiness by 5.1%, length of legs by 3.4%; thoracic index by 2.2%; length by 2.1%; and boniness by 0.6%.

The most important indicator for assessing the effectiveness of the new animal breeding technology is the feed consumption per gain unit (table 5).

**Table 5. Cost of feed per 1 kg of gain in Holstein steers from birth to 18 months on variable feeding.**

| Parameter                      | Group I | Group II |
|--------------------------------|---------|----------|
| Weight gain, kg                | 471.0   | 514.1    |
| Costs per 1 kg of gain:        |         |          |
| feed units                     | 7.39    | 6.87     |
| incl. concentrates of feed units | 2.49   | 2.28     |
| digestible protein, kg         | 0.85    | 0.79     |
| exchange energy, mJ            | 78      | 72.3     |
| Digestible protein per 1 feed unit | 115 | 115      |

The most efficient feed consumption in fattening was observed in Group II; it was lower by 0.52 feed units (7.1%) in comparison with control Group I.

Indices of the meat productivity that depend on the growth of the animal's organism as a whole and individual parts are important for determining the efficiency of a particular technology for livestock raising. Correct assessing of the meat productivity allows reasonable improving methods for beef production technology. The slaughter results of 18-month Holstein steers are presented on the table (table 6).

**Table 6. Meat productivity of Holstein steers on variable feeding.**

| Parameter                      | Group I | Group II |
|--------------------------------|---------|----------|
| Live weight, kg:              | 501.0   | 544.0    |
| removable                     |         |          |
| pre-slaughter                 | 487.3   | 528.0    |
| Weight of fresh carcass, kg   | 264.9   | 295.8    |
| Carcass yield, %              | 54.3    | 56.0     |
| Weight of internal fat, kg    | 16.7    | 18.8     |
| Slaughter weight, kg          | 281.6   | 314.6    |
| Slaughter yield, %            | 57.8    | 59.5     |
| Weight of by-products, kg: I grade | 14.1 | 14.7     |
| II grade                      | 46.7    | 50.1     |
| Yield of by-products, %: I grade | 2.89 | 2.78     |
| II grade                      | 9.58    | 9.49     |

Intensive metabolism of test Holstein steers in Group II allowed obtaining high meat productivity. At 18 months of age, they exceeded their counterparts grown according to the traditional technology in
terms of removable live weight by 43 kg (8%); weight of fresh carcasse by 30.9 kg (10.5%); weight of internal fat by 2.1 kg (11.2%); and slaughter yield by 1.7%.

6. Results
The effectiveness of the variable feeding system that consisted in alternating feeding with two 12-day periods of increasing and then decreasing the ration (in feed units) by 20% was confirmed. The system provided animals with high growth energy and allowed additional increasing in the average daily gain by 8.5%, reducing feed costs per 1 kg of gain by 7.1%, and increasing the carcass weight by 10.5%. If feeding system is applied for Holstein steers younger than 16.5 months of age, the fattening term can be reduced by 1.5 months, with the feed consumption, similar to traditional feeding technology for steers up to 18 months of age. Group II Holstein steers were characterized by a more proportional and harmonious physique and better development of muscles.

7. Conclusion
At the moment, cattle breeding enterprises need to find new methods and ways to reduce resource consumption in the technology of growing steers. One of such methods may be the variable feeding system based on biological growth patterns. A system of that kind can reduce the fattening time to the optimum age for slaughtering livestock and increase the turnover of fixed assets.

Acknowledgement
The authors would like to thank their colleagues for their contribution and support to the research. The work was performed under an RF President grant НШ-2542.2020.11.

References
[1] Fedorov V I 1973 The growth, development and productivity of animals (Moscow: Kolos) p 232
[2] Sipachev S G 1970 The rhythm of animal growth (Tyumen) p 157
[3] Gorlov I F, Randelin AV and Slozhenkina M I 2019 Comparative characteristics of meat productivity of steers of different breeds Dairy and beef cattle breeding 2 18-22
[4] Shevkuzhev A F, Ulimbasheva R A, Ulimbashev M B 2015 Meat productivity of steers of different genotypes depending on beef production technology Zootechniya 3 23-5
[5] Gorlov I F, Slozhenkina M I, Nikolaev D V, Grebennikova Y D and Goryaeva K B 2019 The Impact of innovative fodder additive on the meat productivity and quality parameters of beef Research Journal of Pharmaceutical, Biological and Chemical Sciences 10(2) 272-76
[6] Arthington J D, Eichert S D, Kunkle W E and Martin F G 2003 Effect of transportation and commingling on the acute-phase protein response, growth, and feed intake of newly weaned beef calves Journal of animal science 81(7) 1110-20
[7] Dunshea F R, D'Souza D N, Pethick D W, Harper G S and Warner R D 2005 Effects of dietary factors and other metabolic modifiers on quality and nutritional value of meat Meat Science 71 8-38
[8] Lingyan Li, Yuankui Zhu, Xianyou Wang, Yang He and Binghai Cao 2014 Effects of different dietary energy and protein levels and sex on growth performance, carcass characteristics and meat quality of F1 Angus × Chinese Xiangxi yellow cattle Journal of Animal Science and Biotechnology 5(21) 1186
[9] Murray D 1980 The effect of three different growth rates on feed utilization of cattle Austral. J. agr. Res. 31(6) 1139-45
[10] Sadik A F 1990 Rhythmic-shift feeding of young cattle Zootechniya 1 43-5
[11] Ovsyannikov A I 1976 Fundamentals of experimental work in animal husbandry (Moscow: Kolos) p 304
[12] Getokov O A 2016 The effect of feeding conditions on the meat productivity of young cattle Novainfo 49(1) 92-100
[13] Karatunov V A and Shevchenko A N 2018 Biological features of the growth and development of
Holstein young cattle of Australian selection *Scientific Journal of KubSAU* **136** 223-36

[14] Pshenichny P D and Shevchenko D I 1964 Variable feeding and meat quality of steers *Vestnik of the Russian Agricultural Science* **7** 56-59

[15] Ernst L K and Zinovieva N A 2008 *Biological problems of animal husbandry and the 21st century* (Moscow: RAAS) p 508

[16] Faucitano L, Berthiaume R, D'Amours M, Pellerin D and Ouellet D R 2011 Effects of corn grain particle size and treated soybean meal on carcass and meat quality characteristics of beef steers finished on a corn silage diet *Meat Sci.* **88** 750-4

[17] Traore S, Aubry L, Gatellier P, Przybylski W, Jaworska D, Kajak-Siemaszko K and Santé V L 2012 Higher drip loss is associated with protein oxidation *Meat Sci.* **90**(4) 917-24

[18] Bradlee M L, Singer M R and Moore L L 2014 Lean red meat consumption and lipid profiles in adolescent girls *J Hum Nutr Diet.* **27**(2) 292-300

[19] Sevane N, Cañón J and Dunner S. GemQual 2013 Consortium: Muscle lipid composition in bulls from fifteen European breeds *Livestock Sci.* **160** 1-11

[20] Sevane N, Levéziel H, Geoffroy R N, Sañudo C, Valentini A, John W and Susana D 2014 Phenotypic and genotypic background underlying variations in fatty acid composition and sensory parameters in European bovine breeds *Journal of Animal Science and Biotechnology* **5**(1) 20