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Technological solutions for effective production on beef cattle breeding farms in the conditions of Ukraine

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Abstract. Beef cattle breeding in Ukraine is considered to be a promising and socially important livestock sector, which is experiencing a systemic decline in production. The purpose of the study was to find the most effective options for organizing production in beef cattle breeding. The analysis was based on the production data of an agricultural enterprise with more than 4.5 thousand heads of meat cattle, including more than 1.7 thousand cows. Taking into account the company's

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development strategy, which provided for the expanded reproduction and sale of bull-calves and culled breeding stock, the production indicators of the farm's operation under the cow-calf system and the complete cycle with the rearing of young animals to slaughter conditions were analysed. The analysis of these production options was carried out for the conditions of using year-round and seasonal (from February to April) calving on the farm. It was found that when calving throughout the year, the number of cattle places in the premises and pens will be relatively constant. In the case of seasonal calving, the structure of the herd changes significantly during the year. Sales of finished products during seasonal calving should take place in relatively short periods of time and in large groups. In particular, the monthly sales of bull-calves for fattening in the cow-calf system during seasonal calving will be on average 11 times higher than during year-round reproduction in the herd. With a full breeding cycle, the batches of bull-calves for slaughter will differ less, but will occur only in the spring months. Seasonal calving during the complete production cycle resulted in a 1% reduction in silage and 3% reduction in hay consumption and a 10% increase in pasture grass consumption. The full cycle of raising bull-calves for meat makes it possible to increase the total live weight of cattle sold by 59%, increase sales revenue by 54% and reduce total feed costs per 1 tonne of live weight by 20%. The practical significance of this study is to obtain results that can be used in the Ukrainian beef cattle industry to plan efficient production organization

Keywords: cattle; cow-calf system; fattening; feed costs; beef

Introduction

Ukraine is experiencing a systemic reduction in the raw material base for some types of meat, which is explained by the crisis in livestock production (Ishchuk, 2020). According to the State Statistics Service of Ukraine (Animal production of Ukraine, 2021), in the second half of the last century, meat production of all major types in Ukraine was actively increasing until the early 90s. Subsequently, by 2000, meat production decreased by 62%. The most difficult situation was in cattle breeding, as beef production fell by 83% over 10 years. After this decline, meat production in Ukraine began to grow and has stabilized over the past three years at 2.4-2.5 million tonnes. The stabilization was driven by alternative meat types to beef – poultry (which has doubled in quantity compared to the most productive year in 1990) and partly pork. As of 2021, only 59 kg of all types of meat were produced per capita. With cattle meat production totalling 310.5 thousand tonnes in 2021, the total production of beef and veal per person was only 7.5 kg. According to N. Kopytets & V. Voloshyn (2021), the main producers of beef and veal are households, which account for more than 70% of production, although in 1990, according to the State Statistics Service of Ukraine (Animal production of Ukraine, 2021), this figure did not exceed 9%. The analysis of data on beef production in farms of various forms found that large agricultural enterprises, which should provide the basis for meat production and have the ability to control product safety and form large batches of cattle for slaughter, produce less than 2 kg of beef per person, and their total share in gross production is 26%. This is due to a steady decline in livestock numbers, which continued after 2000, while other competitive livestock sectors were able to stabilize or increase production. Over the past 16 years alone, the number of cattle sold for slaughter by agricultural enterprises has decreased by 60%, which is 7% more than in all categories of farms.

One of the reasons for the decline in beef production is the low economic attractiveness

of its production due to low purchase prices for livestock. Thus, as of April 2021, as noted by V. Ivchenko *et al.* (2021), the average purchase prices for live cattle for slaughter depended on the category of animals, but ranged from UAH 27.9 to 40.5 per kilogram of live weight. In the European Union (Ivchenko *et al.*, 2021), purchase prices for cattle for slaughter are on average 96% higher than in Ukraine, and in some countries (Belgium and Italy), the difference reaches 134-142%. At the same time, the future prospects for beef production are clear. The world is witnessing an increase in demand for quality meat products (Berher, 2020). In an analytical study by N. Eroğlu *et al.* (2019), the authors report that there is a high demand for beef in Turkey and forecast a 14% increase in consumption between 2019 and 2028. This high demand requires finding ways to efficiently produce beef for domestic consumption and increase exports. The problem of producing high-quality beef can be solved by developing specialized beef cattle breeding. There are various systems of beef cattle management that differ in their efficiency. As noted by D. Broom (2021), extensive grazing and the use of feedlots are considered the least sustainable beef production systems, while semi-intensive forest grazing systems and managed grazing systems in areas where crop production is unprofitable are considered the most sustainable. To stabilize beef production in Ukraine, there is a need to find the most efficient beef production systems. The aim of this study was to identify the most appropriate options for organizing production on beef cattle farms.

Literature Review

Since the 1990s, as noted by O. Kozak & O. Hryshchenko (2019), beef production in Ukraine has declined significantly, due to a decrease in the total number of cows and young animals raised for meat production. It was planned to increase beef production by developing specialized beef cattle breeding, as this industry is not related to milk production and can be developed in areas with difficult farming conditions, and beef cattle make efficient use of pastures, natural fodder and post-harvest residues. For this purpose, a 20-year programme for the development of beef cattle breeding was developed by A.A. Getya *et al*. (2013). Meat cattle breeding is of social importance, as it can be developed in remote areas where daily logistics are difficult, and is also effective in areas with low soil fertility (Ugnivenko *et al.*, 2016). Due to the persistent unfavourable changes in the dietary patterns of the population, according to the Institute of Food Resources of the National Academy of Agrarian Sciences (Tymchenko, 2015), the beef cattle industry is strategic in terms of food security, but its condition remains critical.

The main disadvantage of beef cattle breeding is the limited productivity of the cow, which is caused by the ability to raise only one calf per year. In dairy farming, milk is produced during lactation to make up for the cost of maintaining the main herd. Farms that produce both beef and milk have significantly higher productivity of dietary protein and energy per hectare than specialized beef production systems (Mosnier *et al.*, 2021). Raising young dairy cattle for meat does not involve the costs of the rest of the herd. Beef cattle breeding is different. The sale of business calves or young stock bred to the final condition should compensate for the costs of not only this part of the herd, but also for the maintenance and feeding of cows, bulls and replacement stock, so 2-3 times more feed energy is consumed per unit of production in beef cattle than in dairy farms (Ugnivenko *et al.*, 2016). The higher costs of raising beef cattle are compensated by the increased yield, quality, and processability of beef. Beef from specialized breeds has better flavour properties, and some breeds are prone to marbling, which makes beef and crossbred cattle more expensive than dairy cattle (McCabe *et al.*, 2022).

Beef production schemes can vary. The classic option for beef cattle breeding is to organize seasonal reproduction using tour calving and mating campaigns (Ugnivenko *et al.*, 2016). This production option is most suitable for the efficient use of natural fodder lands and cultivated pastures in the spring and summer and reducing the cost of keeping and feeding cows in the winter. Seasonal reproduction makes it possible to carry out complex work operations (such as insemination, calving organization and control, calf weaning, cow evaluation) in a short period of time, as well as to form large levelled groups of animals for further rearing and sale. Raising cattle ready for slaughter usually involves several stages: cow-calf system, rearing and fattening (Peel, 2003). In Ukraine, the production organization with a complete herd turnover is common. In farms, young animals are raised until slaughter on the farm where the breeding herd is kept. P. Putsenteilo (2016) notes that different forms of farm production organization are possible, but it is more advisable to specialize farms. Some farms should raise calves in suckling and sell them to fattening enterprises after weaning of bulls and heifers being already the part of a herd. Fattening plants and sites ensure the final rearing and production of young cattle with optimal slaughter conditions. Specialization of farms at different stages of beef production allows for more efficient use of resources and feed. According to A. Ugnivenko *et al*. (2016), young cattle need to be provided with fast growth on the background of balanced nutrition to effectively use the biological basis for muscle tissue development, and breeding herds should be kept using extensive technologies and maximum use of pastures and natural lands to reduce costs. With these features in mind, beef cattle breeding herds can be part of natural ecosystems. It is recommended to use them to increase the ecological and recreational value of the forest and reduce the likelihood of fires (Casasús *et al.*, 2007), as moderate grazing reduces the amount of shrubs and dry grass.

The efficiency of raising livestock for meat also depends on the sex of the animals. Bull-calves tend to be more productive, so according to H. Koknaroglu *et al*. (2005), they are used more often in fattening enterprises. Improvements in technology and breeding are gradually increasing the productivity of beef cattle. In particular, the live weight of calves at the time of weaning is constantly increasing. According to American researchers (Lalman *et al.*, 2019), from 1983 to 2017, there was an increase in the live weight of weaned calves, which, taking into account variability in the areas where farms are located, averaged 0.5 kg per year. Significant progress has also been made in a number of other livestock productivity traits.

The attractiveness of beef cattle breeding depends on economic indicators. Prices for fattened cattle account for approximately 50% of the variation in profitability and depend on the balance of the market. In countries with developed beef cattle production, such as Australia, J. Wong (2020) notes periodic fluctuations in slaughter cattle prices due to waves of demand for commercial cattle and breeding stock for herd reproduction. The use of techniques to increase cattle productivity using growth stimulants and other technological methods affects consumer perceptions and has led to increased demand for beef produced without stimulants, the production technology of which is being actively researched (Aboagye *et al.*, 2021). Among the options for producing high-quality beef are (Archer *et al.*, 2004) grass-fed (high volume diets using pastures, green mass and hay, balanced with other feeds and additives) and grain-fed (highly concentrated diets). In other words, there is a wide variety of options for organizing beef production in the world, and in Ukraine, the search for the most rational organization of the technological process remains relevant.

Materials and Methods

The research was carried out by analysing various options for the cultivation and sale of

livestock, calculated based on the results of production activities in 2021-2022 of one of the agricultural enterprises of Ukraine, with a livestock population of more than 4.5 thousand heads of beef cattle, including more than 1.7 thousand cows of several specialized breeds (in particular, Aberdeen Angus, Charolais, and Limousin, and Hereford). No animals were directly involved in the study. For ethical reasons, the name of the private enterprise on the basis of which the study was conducted will not be disclosed, as the publication contains sensitive data on production volumes and sales prices. The company's beef cattle production had a complete cycle. The breeding stock was used employing the cow-calf technology. Weaned calves aged 6-8 months were separated by sex and put to grow. Bull-calves were sold for meat at the age of 12-14 months. The breeding stock with calves were kept on pastures in summer and in group untethered housing in winter. The bull-calves for growing and fattening were kept indoors in group sections formed by age and fed a mixed diet. Calving in the herd was year-round but uneven throughout the year. Reproduction in the herd was extended, with almost all heifers suitable for reproduction being bred and inseminated at the age of 14 to 18 months. The general parameters of breeding and reproduction are shown in Table 1.

Table 1. *Parameters of reproduction of livestock and cattle rearing*

Indicator	Value
Culling of cows, %	12
Yield of calves per 100 cows, %	84
The average age of introduction of heifers into the herd, months	24
Die-off and culling of suckling calves, %	3.5
Duration of the suckling period, months	7
Live weight of weaned calves, kg	250
Age of sale of bull-calves for meat, months	12-14
Live weight of bull-calves during sale for slaughter, kg	450

Source: author's development

The study examined the efficiency of production organization at the enterprise under conditions of year-round calving of cows (used on this farm) and the transition to seasonal reproduction, which is used in beef cattle breeding in most temperate countries. The study used data on livestock availability, animal reproduction and growth parameters, and the enterprise's development strategy. Two models of final product production were studied under two options for organizing livestock reproduction. The first model is the cow-calf system, where weaned bull-calves are sold for growing and fattening. The second model is a complete production cycle, with the sale of bull-calves for slaughter. Heifers were not included in the sales plan due to the farm's strategy of expanded reproduction in the coming years. In both models, cull cows and bulls were used as additional products, so their number and live weight were determined. The study determined the optimum live weight of bull-calvess for meat production, analysed the features of the production cycle, the annual dynamics of production and output of finished products, the need for feed for different production options, annual production volumes and the cost of final products, and feed consumption per cent of beef produced. Feed consumption was calculated using the rations of livestock of different production groups used on the farm (Table 2).

Table 2. *Daily feed requirement and structure of rations for production groups*

Indicator	Sex and age groups of livestock						
	cows	heifers	repair heifers	suckling heifers	suckling bull-calves	bulls	fattening bull-calves
Fodder requirement for 1 head, fodder unit	10	6.7	6	3	3.5	13.5	7
the structure of the diet in the autumn-winter period							
silage, %	34.8	34.8	50	34.8	34.8	34.8	10
compound feed, %	33.2	33.2	24	33.2	33.2	33.2	78
hay, %	15.2	15.2	17	27	27	27	12
straw, %	11.8	11.8	9	—	—	—	—
the structure of the diet in the spring-summer period							
compound feed	29	29	20	29	29	29	*
green fodder (pastures)	71	71	80	71	71	71	*

Notes: * fattening bull-calves are grown year-round on diets that correspond to the autumn-winter period in terms of composition and structure

Source: author's development

The duration of the spring-summer period, during which pasture fodder is used, was from May to September inclusive. The energy value of fodder was determined in fodder units, since reporting and statistical information in the economy is provided in these units of measurement.

Results and Discussion

To ensure the efficient functioning of farms in meat cattle breeding, the substantiation of the requirements for livestock that will be sold for slaughter becomes important. The main characteristic of cattle for slaughter is pre-slaughter live weight. This factor affects the duration of the production cycle on the farm and also affects feed costs, quality, and mass of carcasses, etc. The choice of criteria for establishing the optimal live weight of young animals for slaughter is quite wide, but considering that high-quality and elite beef is obtained from specialized meat cattle, and the steak part has the highest value among carcass cuts, it was accepted to focus on the weight of bull-calves during the period of cessation of active growth of the longest muscle of back widthwise. According to the research of A. Ugnivenko *et al*. (2022), carried out in Ukrainian meat and black-and-white dairy breeds, the largest cross-sectional area *m. Longisimus dorsi* in the area between the 12th and 13th ribs is manifested when the live weight of bull-calves is from 451 to 500 kg (Fig. 1).

At a live weight of up to 450 and over 500 kg, the area of the "muscle eye" of the studied breeds was smaller. Since the live weight of bull-calves of 450-500 kg under conditions of intensive breeding can be obtained at an early (12-14 months) age, when bull-calves have relatively low fat deposition and moderate feed consumption for live weight gain, this weight range should be considered optimal. Production on a beef farm can take place in the form of an unfinished cycle according to the "cow-calf" system, during which the young weaned from cows are sold for fattening in other enterprises and the finished cycle of production with the sale of young for slaughter. The production cycle on such farms differs significantly both in terms of structure and duration (Fig. 2). The start of production according to the "cow-calf" system corresponds to the time of insemination of cows and heifers, and the production cycle

includes fattening and suckling calves. The full duration of the production cycle until obtaining marketable products on such a farm is 16 months, but taking into account the fact that cows partially combine the next calving and previous lactation, the technological process lasts 12 months, with the receipt of weaned calves every year.

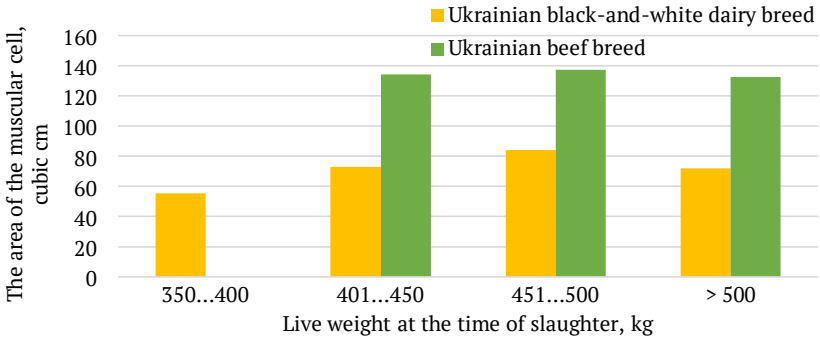

Figure 1. The area of the muscular cell of bull-calves, depending on the live weight before slaughter

Source: A. Ugnivenko et al. (2022)

On a farm with a finished cycle of production in the broodstock, the production cycle includes the same periods, but after weaning of the calves, rearing and fattening of the young is added. The total duration of the production cycle on such a farm will be 6 months longer than the "cow-calf" system. The extension of the production cycle contributes to the increase in the number of livestock on the farm, but due to the extended cultivation of young animals, it will contribute to the growth of the gross live weight of the reared livestock.

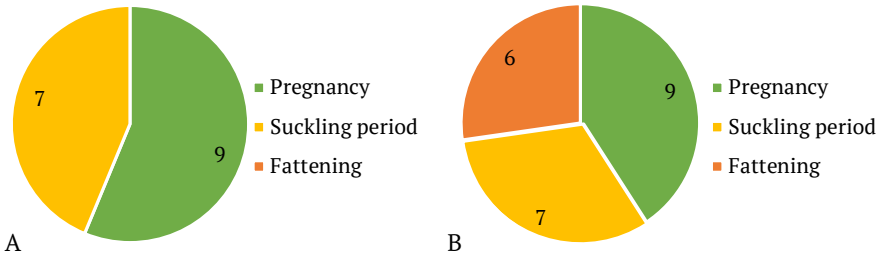

Figure 2. Duration of the production cycle on the farm (months) using the cow-calf system (A) and the completed production cycle (B)

Source: author's development

In addition to the duration of the production cycle, it is possible to use two different forms of organization of livestock reproduction in beef cattle breeding, in particular year-round and seasonal calving. There is an opinion that seasonal calvings have certain advantages over year-round calvings, due to the consolidation of labour-intensive operations (calving, insemination), the ability to form large homogeneous groups of animals and the most optimal use of pastures. At the same time, a detailed comparison of these forms of organization of reproduction of beef cattle in the conditions of Ukraine was not carried out.

The movement of livestock throughout the year under the conditions of year-round calving with their distribution maintained throughout the year and seasonal calving in February-April was modelled, which is provided by tour mating campaigns in May-July. Under the conditions of obtaining year-round calving at the beginning of the year, the total number of cattle is 4.882 heads, and for seasonal reproduction it is 310 heads less (Table 3). The decrease in herd size during seasonal calvings is due to the peculiarities of the organization of the production process and the redistribution of livestock, in particular, there will be no suckling calves at the beginning of the year.

Table 3. *Population of cattle of different gender and age groups*

No.	Sex and age groups of beef cattle	Number of heads	
		for year-round calving	for seasonal calving
1	Cows	1752	1752
2	Heifers	726	867
3	Repair heifers (over 7 months of age)	922	961
4	Suckling heifers	453	—
5	Suckling bull-calves	450	—
6	Bull-calves from 7 to 14 months	577	961
7	Bulls	22	22
	In total	4882	4572

Source: author's development

The dynamics of livestock in groups of livestock, under different options for the organization of reproduction, is shown in Figures 3 and 4. Under the conditions of obtaining relatively uniform calvings throughout the year, a trend of a gradual increase in the number of cows, which is provided for by the strategy of expanded reproduction of the herd, is clearly observed. The growth of the brood stock will reach 36% for the year. In all groups, the number of cattle during year-round calving will be relatively stable. This implies the need to have a certain number of places in the premises and pens to keep the corresponding accounting groups of livestock, and the filling of sections for keeping animals will be relatively constant.

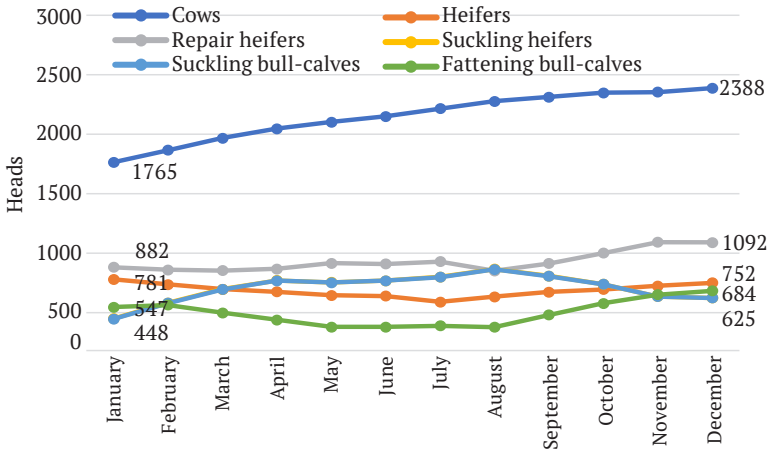

Figure 3. Size of livestock groups with relatively uniform calvings throughout the year
Source: author's development

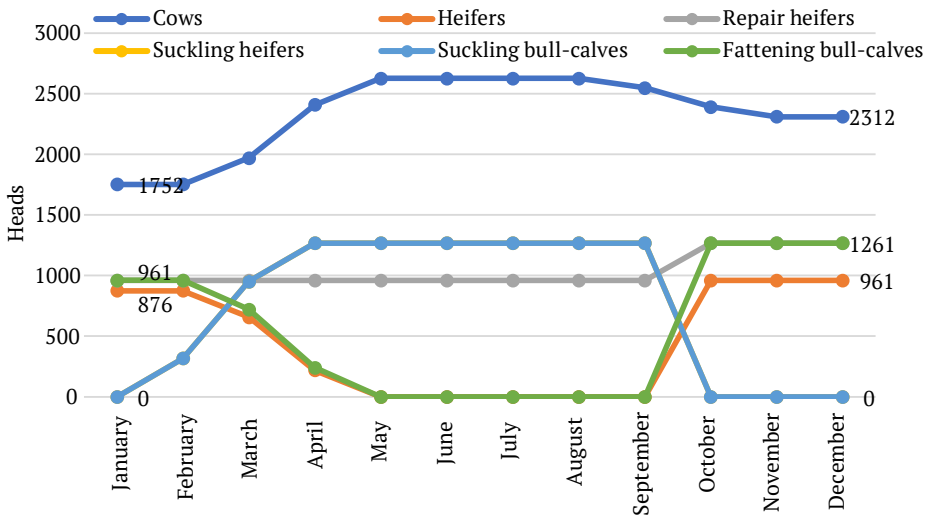

Figure 4. The size of livestock groups for obtaining seasonal tour calvings
Source: author's development

With seasonal tour calving, the year-end increase in the number of cows will reach 32%, which is 4 percentage points less than with year-round calving. The difference is due to the way cows are culled, as with seasonal calving they are removed from the herd in the autumn, before the start of the winter period, while with year-round calving they are gradually removed. The structure of the herd changes significantly during the year with seasonal calving. In particular, fattening cows and heifers are in the herd only from October to April, while suckling calves are in the herd from February to October. During most of these periods, the number of cattle in the groups is at its maximum level and hardly changes. For example, from April to September, the number of suckling calves with cows will be more than 2.5 thousand. This simplifies the organization of care for cows with calves, but requires large areas in pens and premises. For comparison, with year-round calving, suckling calves will be in the herd all year round, but their number will range from 0.9 to 1.7 thousand. The solution to the problem of space for cows with suckling calves is to use pasture-based housing. Thus, in farms with pasture, the organization of seasonal calving will be more appropriate. Year-round calving reduces the need for headspace by levelling the number of cattle groups throughout the year, and is more appropriate on farms that do not have sufficient pasture or are focused on rearing animals in pens.

An important element of production on beef cattle farms is the sale of finished products. With year-round calving, the production of livestock groups will be spread over the whole year, while with seasonal calving, the sale of animals should take place in relatively short periods of time (Fig. 5).

With year-round calving, a cow-calf farm can sell groups of bull-calves ranging from 38 to 198 head for fattening each month. The difference in the size of the weaned calf product groups will depend on the uniformity of calving throughout the year. In the case of seasonal calving, weaned calves are received in October. The group of bull-calves to be sold for fattening will be about 1.3 thousand heads. This is numerous bulls, which increases the risk of lower prices or delays in sales, which in turn are associated with additional feed costs.

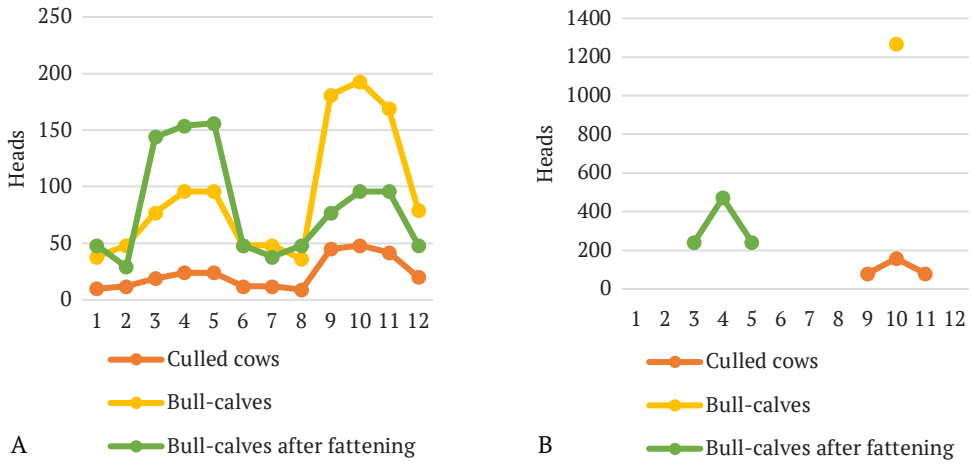

Figure 5. Predicted dynamics of production of the main types of products during the year for year-round calvings (A) and seasonal calvings (B)

Source: author's development

A similar situation exists with the sale of cattle from a farm with a complete cycle of growing young stock. With year-round calving, groups of bull-calves for slaughter ranging from 38 to 156 heads and cull cows from 10 to 48 heads are formed every month. The gradual sale of relatively small groups of cattle allows forming long-term contracts with processing companies on the most favourable terms. Receiving large batches of bull-calves for slaughter that need to be sold within three months requires finding wholesale buyers capable of processing such livestock. Under conditions of synchronized production on other farms with seasonal reproduction, there may be a period of oversupply, followed by a long period of lack of cattle for slaughter.

The system of production organization in beef cattle breeding can affect the use of different types of feed by livestock, which is due to changes in the structure of the livestock herd during the year (Table 4).

Table 4. *The need for fodder for a herd of beef cattle per year*

Sex and age groups of livestock	The need for fodder, quintals				
	silage	compound feed	hay	straw	greens (grass)
Year-round reproduction of livestock					
Cows	76842	21118	16782	23687	118792
Heifers	17850	4610	3898	5502	23211
Repair heifers	29997	3942	5100	4909	33077
Suckling heifers	7027	2088	2726	—	12986
Suckling bull-calves	8179	2432	3173	—	15130
Bulls	1139	304	442	—	1613
Fattening bull-calves	3599	8544	4319	—	—
In total	144633	43038	36440	34098	204809
Seasonal calving					
Cows	77606	22906	16948	23922	141203
Heifers	18977	3200	4144	5850	729
Repair heifers	34152	4385	5806	5588	35288

Table 4. Continued

Sex and age groups of livestock	The need for fodder, quintals				
	silage	compound feed	hay	straw	greens (grass)
Suckling heifers	3986	2129	1546	—	20662
Suckling bull-calves	4654	2485	1806	—	24105
Bulls	1173	352	455	—	2219
Fattening bull-calves	3973	9431	4767	—	—
In total	144521	44888	35472	35360	224206

Source: author's development

The analysis of feed requirements for a calendar year showed that the use of year-round and seasonal calving did not lead to significant changes in the use of different types of feed measured in kind. With seasonal calving, there is a slight decrease in the need for silage (up to 1%) and hay (up to 3%) and a 4% increase in the need for compound feed and 10% increase in pasture grass. This difference is not critical for the farm and is less than the loss of some types of feed during storage and feeding. Thus, in farms with a complete production cycle, the annual ration structure will not significantly depend on the distribution of calving throughout the year. The total annual production volumes on a farm with seasonal and year-round calving differ slightly (Table 5). This is partly due to the shift in production of final products from year-round calving to the following year.

Table 5. *Volumes of production on the farm for the year*

Indicator	A group of animals for realization		
	cow-calf system (weaned bull-calves for fattening)	culled cows (bulls)	finished production cycle (bull-calves for slaughter)
Year-round reproduction of livestock			
Implementation per year, heads	1109	277 (7)	982
Live weight of 1 head, kg	250	550 (900)	450
Gross live weight, quintals	2772.5	1586.5	4419.0
Cost of gross live weight, thousand UAH	26061.5*	6187.4**	40212.9***
Seasonal calving			
Implementation per year, heads	1268	316 (7)	952
Live weight of 1 head, kg	250	550 (900)	450
Gross live weight, quintals	3170.0	1801.0	4284.0
Cost of gross live weight, thousand UAH	29798.0*	7023.9**	38984.4***

Notes: Cattle sales prices are calculated per 1 kg of live weight. * The expected sale price of bull-calvess for further fattening is UAH 94, taking into account the sale prices of young animals for slaughter of the I category; ** Selling price of cows and bulls for slaughter is UAH 39. The ratio of the shares of animals of different categories is taken into account in the calculation. Cows: lean – 30%, category I – 35%, category II – 45%. *** The selling price of bull-calves for slaughter is UAH 91. The ratio of the shares of animals of different categories is taken into account in the calculation. Bull-calves, I category — 85%, II category — 13%, sale of cattle — 2%. Cattle categories for slaughter were determined according to DSTU 4673:2006 (2011)

Source: author's development

With expanded reproduction and year-round calving, the full cycle of rearing young animals for meat makes it possible to increase the total live weight of sold young animals by

59% and revenue from their sale by 54% compared to the cow-calf system. In the case of seasonal calving, the difference between the different options for organizing the farm's work is smaller, due to the receipt of weaned calves at the same time throughout the year. In particular, the full cycle of growing young animals makes it possible to increase the live weight of bull-calves for sale by 35% and their total cost by 31%. After the farms switch to a simple reproduction system, there will be no difference in the number and live weight of cattle for slaughter or fattening during seasonal and year-round calving, but the full cycle of rearing will significantly increase the number of marketable products.

Due to the extended rearing of young animals on a farm with a complete production cycle, more feed is consumed. In order to estimate the feed consumption per total live weight of livestock intended for sale, we added the gross live weight of culled cows and bulls to the weight of weaned calves intended for fattening (cow-calf system) and bull-calves raised for slaughter (full cycle of rearing). The results of the analysis are shown in Table 6.

Table 6. *Feed costs per 1 kg of live weight of livestock, depending on the final product production option*

Indicator	Cow-calf system (the main product is weaned bull-calves for fattening)	finished production cycle (the main production is bull-calves for slaughter)
Year-round reproduction of livestock		
Total weight of livestock for sale, quintals	4359.0	6005.5
Annual costs of fodder on the farm, quintals fodder unit	132458.1	145054.9
Feed consumption per 1 kg of live weight, kg of fodder unit	30.3	24.2
Seasonal calving		
Total weight of livestock for sale, quintals	4971.0	6085.0
Annual costs of fodder on the farm, quintals fodder unit	136846.2	150751.0
Feed consumption per 1 kg of live weight, kg of fodder unit	27.5	24.8

Source: author's development

The total feed costs take into account the feeding needs of all livestock groups, but they are recouped only through the sale of calves intended for fattening or bull-calves bred for slaughter and cull cows and sire bulls. The clear result is that per 1 kg of live weight of all livestock intended for sale, feed consumption will be higher when the farm operates under the cow-calf system. On a farm with year-round calving, with a full cycle of growing and fattening young animals, the total feed costs per 1 kg of live weight of cattle intended for sale will be 20% lower. The complete cycle of rearing bull-calves for meat during seasonal calving allows for a 10% reduction in feed consumption per 1 tonne of live weight. When comparing the efficiency of feed use on a farm with a complete cycle of growing young stock for seasonal and year-round calving, no significant difference in feed consumption was found. The difference of up to 10% was for the cow-calf system, which is explained by the receipt of some weaned calves in the following year, which led to worse performance in year-round calving.

This study presents a simulation model of a beef cattle population based on actual data and

component variables that can be used to compare the effectiveness of technical strategies on a farm. A similar technique has been used to evaluate the most efficient model of cattle reproduction and, according to O.A. Ojeda-Rojas *et al*. (2021), this research method has all the advantages over a physical experiment, as it does not require significant costs and changes to the actual production system on farms before the final result is obtained.

A. Ugnivenko *et al*. (2016) believe that the cow-calf technological operation is the main, most complex and important for obtaining healthy and cheap calves for fattening. It includes all types of work during the inter-calving cycle of a cow, including insemination of the breeding stock grazing on pastures, organization of feeding and housing during the stall period. All of this should be done with economical use of labour and inputs so that calves are not too expensive after weaning. The author of the publication argues that it is advisable to use seasonal (mainly early spring) calving in beef cattle herds, with calves weaned in autumn. The current study did not confirm a clear advantage of early spring calving. There was a slight redistribution of the need for different types of feed, which had almost no effect on the total cost of feed per cent of live weight of livestock intended for sale. At the same time, seasonal calving is associated with obtaining marketable cattle in short periods, which creates risks of its sale, although the cultivation of homogeneous groups of animals is easier in terms of technology. M. Michaličková *et al*. (2015) argue that strict adherence to the principles of seasonal reproduction of beef cattle, with calving in January-March, is critical for a cow-calf system, as it facilitates efficient grazing management and reduces feeding costs during spring. When deciding on the option of organizing reproduction on a farm, it is also advisable to consider the impact of the season on livestock productivity and value. It was found (Titterington *et al*., 2017) that cows calving in June had the shortest and November the longest period between calvings. G.W. Henry *et al*. (2016), based on an analysis of 19 years, determined that autumn calving was more profitable than spring calving for different diets and weaning ages, due to changes in the price of weaned calves. These data confirm the conclusions that the use of year-round calving allows for a relatively even distribution of the positive and negative effects of year factors on livestock productivity and sales prices. In the case of seasonal reproduction, it is important to carefully justify the period of mass calving, taking into account the peculiarities of fodder production, cyclical changes in livestock productivity throughout the year and prices for calves and young animals for slaughter.

The study found that in terms of conversion of feed into live weight of commercial cattle, own fattening is more efficient than production under the cow-calf system. But in the studies of A.R. Huerta *et al.* (2016), it was found that the organization of in-house fattening has a number of other risks, including water depletion, terrestrial ecotoxicity, photo-oxidant formation, freshwater ecotoxicity, etc. that need to be taken into account when setting up a farm. In the context of climate change and the depletion of natural resources, the option of organizing beef production is of great importance. Young beef cattle can be raised for meat using semi-intensive pasture and intensive feedlot systems. The use of extensive systems significantly increases the need for feeding areas. The feasibility of building fattening complexes with intensive cattle breeding for meat is evidenced by the 64% saving compared to irrigated pastures (Broom, 2019).

The study was conducted in an intensive farming area, where field forage production ensures high yields of fodder crops and makes it possible to provide a full cycle of livestock production within one enterprise, from the cow-calf system to the sale for slaughter. However, this production system may have limitations in other environments. The study by Y. Liu *et*

al. (2023), conducted in Inner Mongolia (China), found that in beef cattle breeding areas where effective feed supply has not yet been established, it is difficult to meet the needs of numerous cattle, so own feeding can lead to stunted growth of young animals and negatively affect income. In Canada, different types of farms are widespread, ranging from exclusively cow-calf to exclusively feedlot production. S.C. Sheppard *et al*. (2015) note that the production organization of farms is significantly dependent on natural and climatic conditions, and production systems in the prairies differ from those in the eastern provinces of Ontario and Quebec. In particular, the prairies have earlier and shorter calving seasons, winter grazing, barley-fed diets with a lower proportion of corn, and more seasonal feeding zones. In Ukraine, the organizational system of beef cattle farms should also take into account the natural and climatic conditions and availability of feed resources, but with the fact that the price of cattle is much lower than in many countries with developed livestock production, as reported by V.M. Ivchenko *et al.* (2021), it is currently advisable to produce beef from beef cattle in a complete production cycle and under conditions of own efficient pasture and field fodder production with high quality and low cost of feed.

Another factor in the efficiency of beef cattle herds is the duration of cow use. The farm we used as a baseline for our analysis relies on extended reproduction with long-term productive use of cows (on average, about 8 years). Studies conducted by A.G. Sessim *et al.* (2020) confirm the feasibility and expediency of this approach. In particular, they point out that the economic efficiency of a farm depends on cows remaining in the herd as long as possible, the best cow efficiency indicators are for culling cows at the age of 13, and for farms – when culling cows at the age of at least 6 years. In other words, the cow-calf system is most efficient when cows reach full maturity in terms of age and live weight. This creates effective prerequisites for the expanded reproduction or sale of over-repair heifers.

Thus, to ensure efficient production in beef cattle breeding in Ukraine, farms should focus on the full cycle of obtaining, growing and fattening cattle to a live weight of 450-500 kg and the long-term use of cows in the herd. The decision to introduce seasonal or year-round reproduction should be made taking into account the availability of production areas and rational approaches to selling cattle for slaughter.

Conclusions

The development of the beef cattle industry is possible only if the most efficient model of farm operation is chosen. The analysis of production options on a beef cattle farm showed a significant advantage of the complete production cycle over the cow-calf system. With the cow-calf system, the production cycle is shorter by 6 months and total feed costs are approximately 10% lower, but with a full cycle of growing young cattle for meat, the total live weight of cattle for sale can increase by 59%, which makes it possible to reduce feed costs per 1 tonne of live weight by up to 20%.

The seasonality of calving, which is traditionally used in beef cattle breeding to improve production efficiency, does not have a clear positive impact. In addition to increasing the productivity of cattle calving at certain periods of the year, as pointed out by the authors of a number of literature sources, tour calving allows cattle to be sold in a short time. Receiving large batches of livestock for sale increases the risks for beef cattle farms and limits the flow of funds for most of the year. The production effect of using seasonal tour calving is a slight redistribution of the share of different types of feed, an increase in the need for pasture grass and a decrease in hay and silage. Early spring calving is advisable for farms that operate a cow-calf system and rely on pasture as the main source of feed. With a complete cycle of

raising cattle for meat and fattening them on the farm, the difference in feed requirements for different types of feed will be insignificant.

To ensure efficient production in Ukraine, it is advisable to combine the cow-calf system and a complete cycle of growing bull-calves for meat on beef cattle farms. The decision on seasonal reproduction of cattle using tour calving should be made taking into account the type of fodder lands, availability of production areas on the farm and the possibility of profitable sale of cattle. Prospects for further research are to study the most effective schemes for organizing the feeding of beef cattle in different phases of the production cycle, taking into account the natural and climatic zones of farms, the characteristics of available feedlands and the impact on cattle health and beef quality.

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Conflict of Interest

None.

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Технологічні рішення ефективного виробництва на фермах з розведення м'ясної худоби в умовах України

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Анотація. М'ясне скотарство в Україні вважають перспективною та соціально значимою галуззю тваринництва, в якій спостерігають системне скорочення виробництва. Мета дослідження полягала в пошуку найбільш ефективних варіантів організації виробництва у м'ясному скотарстві. Для проведення аналізу використані дані виробничої діяльності сільськогосподарського підприємства з поголів'ям понад 4,5 тис. голів худоби м'ясного напряму продуктивності, зокрема більше 1,7 тис. корів. З урахуванням стратегії розвитку підприємства, яка передбачала розширене відтворення і реалізацію бугайців та вибракуваного маточного поголів'я, було проаналізовано виробничі показники від роботи ферми за системою «корова-теля» і закінченого циклу з вирощуванням молодняку до забійних кондицій. Аналіз цих варіантів організації виробництва проводили для умов

використання цілорічних і сезонних (з лютого по квітень) отелень на фермі. Виявлено, що за отримання отелень впродовж року кількість головомісць в приміщеннях і загонах буде відносно сталою. За сезонних отелень структура стада впродовж року змінюється суттєво. Реалізація готової продукції за сезонних отелень повинна відбуватись у відносно короткі проміжки часу та великими групами. Зокрема місячна реалізація бугайців для відгодівлі за системою «корова теля» за сезонних отелень буде в середньому у 11 разів більша, ніж за цілорічного відтворення в стаді. За повного циклу вирощування партії бугайців для забою будуть відрізнятись менше, але припадатимуть лише на весняні місяці. За сезонних отелень під час закінченого циклу виробництва виявили зменшення потреби в силосі до 1 % і сіні до 3 % та збільшення потреби в пасовищній траві на 10 %. Повний цикл вирощування бугайців на м'ясо дає можливість збільшити загальну живу масу реалізованої худоби на 59 %, виручку від реалізації на 54 % та зменшити загальні витрати кормів на 1 ц живої маси на 20 %. Практичне значення даного дослідження полягає у отриманні результатів, які можуть бути використані в м'ясному скотарстві України для планування ефективної організації виробництва

Ключові слова: велика рогата худоба; система «корова-теля»; відгодівля; витрати кормів; яловичина