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Integrated assessment of bulls of precocious meat breeds of English selection in the conditions of Ukraine

V. S. Kozyr
izkzoo3337@gmail.com

Institute of Grain Crops NAAS, 14 Volodymyra Vernadskoho str., 14, Dnipro, 49009, Ukraine

ORCID:
V. S. Kozyr https://orcid.org/0000-0002-0275-475x

Authors' Contributions:
KVS: Conceptualization; Data curation; Formal analysis; Investigation; Methodology; Project administration; Supervision; Writing — original draft, review & editing.

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An integrated assessment of the productivity of precocious Hereford and Aberdeen Angus beef bulls of English breeding in the Ukraine Steppe zone conditions was carried out. It has been established that livestock from the seaside climate have adapted to the dry, hot environment of the Steppe zone, as evidenced by the clinical indicators of the animals' bodies. Livestock developed harmoniously, external measurements and indices of body structure were within the limits of breed standards. Hereford and Aberdeen Angus breeds bulls under pasture-free maintenance and rearing conditions for up to 2.5 years at the end of fattening had high productivity — 688 and 531 kg of body weight, respectively. The bulls were with a harmoniously developed body and perfectly expressed meat forms. The bulls were of compact build with a developed deep chest, a full back part of the body, which is characteristic of cattle with a strong constitution and potentially high meat productivity. The relative growth rate of the bulls during the study was in the range of 19–22%. Therefore, Hereford and Aberdeen Angus breeds are the future of meat cattle breeding in Ukraine to increase the production of high-quality "marble" beef. Compared to Aberdeen Angus, Herefords differ in slightly larger habit, massiveness, growth energy, feed conversion, slaughter indicators, balanced morphological composition of carcasses, meatiness ratio. Absolute and relative increases in body weight confirm the high genetic potential of meat productivity — 18–24-month-old bulls have reached sales conditions. Today, their number is small, and reproduction requires a certain amount of time and money, so we believe that the breeding period can be extended to 30 months. In the period of formation of the meat cattle breeding industry, it is possible to raise young animals up to 30 months of age without deterioration of slaughter performance and culinary and taste qualities of beef in accordance with consumer requirements.

Key words: cattle, breed, bulls, exterior, meat productivity, slaughter indicators, beef quality

Introduction

In countries with developed cattle breeding, beef is mainly obtained from specialized meat breeds. In Ukraine, this industry is in the stage of formation, and dairy cattle are used for slaughter, the meat of which has much lower quality. Therefore, a lot of livestock is imported into the country to participate in the creation of meat cattle breeding and the breeding of domestic meat types and breeds. The productivity of beef cattle genotypes was studied by many domestic and foreign scientists [12, 14]. The most common short-ripening Hereford and Aberdeen Angus breeds [15].

Hereford is the most numerous breed of cattle in the world. It was bred in United Kingdom. The world association for this breed includes more than 25 national associations, including two such organizations in the USA and Australia. They were brought to Ukraine from UK, the USA and Canada.

The widespread distribution and popularity of this breed was achieved due to excellent adaptation to different climatic conditions (from the frosts of northern latitudes to subtropical heat), relatively economic precociousness of animals, good fertility, easy calving, calm temperament, ability to effectively use plant fodder and rapid growth of meat forms and outstanding performance. The live weight of adult cows is 500–600 kg, in bulls it is over 1000 kg. Livestock is not high in comparison to others. These qualities are persistently transmitted to offspring not only during purebred breeding, but also during industrial crossing.

In Ukraine, Herefords are used in the creation of new high-yielding meat genotypes with a strong constitution. For science and practice, it is expedient to study how purebred cattle behave in the rather difficult pasture-free climatic conditions of the steppe zone, how these conditions affect the intensity of their growth in different age periods, to what live weight and age animals should be raised for meat in order to obtain the maximum the amount of high-quality beef with the optimal ratio of muscles and bones, protein and fat, lower consumption of feed per unit of production.

The Aberdeen Angus cattle breed is native to the counties of Aberdeen and Angus in northeastern Scotland. It was bred in the 19th century and has the most pronounced precocious type, widely distributed in countries with developed meat cattle breeding — USA, Canada, Argentina, Australia, New Zealand.

Aberdeen Angus cattle began to be imported to Ukraine from England in 1932, and a particularly large number of them arrived in 1960–1964 from Canada. Breeding and genetic work with them was carried out from the beginning of the seventies of the last century at the experimental station of meat cattle breeding of the National Agrarian University (Vorzel, Kyiv Region) under the leadership of Professor O. G. Timchenko [14].

Bulls and cows imported from UK are large with well-defined meat forms compared to Canadian ones, which are more angular, have a strong and rough skeleton, a heavy head. The young, obtained from reciprocal crossings of animals of Canadian and Scottish origin, grew and developed normally. There is practically no barrenness and abandonment of newborn calves. The results of crossbreeding Aberdeen Angus with Simmentals, Charolais, Herefords, Kianas, Ukrainian black and white cattle were used by O. G. Tymchenko with the breeding of domestic Volyn and Znamyan meat breeds. He came to the unequivocal conclusion that Aberdeen Angus were satisfactorily acclimatized in different soil and climatic zones of Ukraine, are not demanding on coarse feed (they eat straw of winter cereals well).

Despite the fact that this breed was created for pasture keeping, it feels comfortable in stall-walking keeping as well. According to S. Ya. Dudik and A. V. Lanyna cows of this breed have sufficient milk yield to raise a calf with a body weight of 200 kg for up to 7–8 months.

Herefords and Aberdeen Angus were also brought to Dnipropetrovsk region for this purpose. The reproductive function of heifers and cows was within such limits as in their homeland. Embryonic development of the fetus and hotels took place without abnormalities. Growth of newborn calves was also normal. Observations did not reveal any external defects. All the measured measurements of the animals were within the limits typical for specialized meat English breeds. The body of cattle of both breeds was tub-shaped with well-developed trunk muscles.

Our long-term (up to 30 months) studies of the ontogeny of bulls in the steppe zone of Ukraine established that they are well acclimatized to the ecological conditions of a hot, dry climate when they are kept without pasture. This is evidenced by clinical and hematological indicators. Physiological processes in the animals' body were within normal limits. Edibility of traditional rough forages (straw of winter wheat and barley), silage from corn of milk-wax maturity and silage from alfalfa, green mass of corn and alfalfa, finishing feeds (combined fodder from grain corn, wheat, barley, peas, sunflower meal), mineral additive (tricalcium phosphate), trace elements were at the level of 97–98%.

Meat productivity (average daily gains) corresponded to the breed standard, it increased in the first months of life, and after 24 months of age it gradually decreased due to the slowing down of muscle tissue growth and the outpacing growth rate of fat synthesis (body salting). Slaughter parameters (slaughter yield, carcass and offal yield, meatiness ratio, beef marbling, protein-to-fat ratio, calorie content, culinary and taste qualities) were such that they met the needs of the consumer.

Despite the fact that both breeds are precocious and have a great uniformity of many indicators, Hereford and Aberdeen Angus bulls had some breed characteristics, which prompted the urgency of conducting research.

The purpose of the research is to study the peculiarities of the ontogenesis of Hereford and Aberdeen Angus bulls in the Ukraine steppe conditions. The subject of research is bulls of specialized precocious meat breeds of Great Britain. The object of research is the growth, development and meat productivity of bulls from birth to 30 months of age.

Materials and Methods

Two groups of clinically healthy Hereford and Aberdeen Angus breeds (15 bulls in each group) were formed in the research farm "Polyvanivka" of the Institute of Grain Crops NAAS. The animals were raised in the same room under the same climatic, technological and feed conditions from birth to 30 months of age.

Rations by age periods were balanced according to the norms. Distribution of fodder, watering of animals and cleaning of the premises was mechanized.

Growth was studied according to the external indicators of body measurements, development — according to live weight (monthly weighing), absolute and average daily growth at birth, at 6, 12, 18, 24 and 30 months. Hematological studies were performed in the certified laboratory of the Dnipro State Agrarian and Economic University. Modern biochemical, zootechnical, economic, statistical, analytical methods were used during constant observation of animals.

Results and Discussion

Clinical indicators of experimental animals of both breeds indicate that they are well acclimatized in the steppe zone of Ukraine and were healthy during all periods of observation (table 1).

The body temperature and pulse and breathing rates in the bulls were within the average limits for cattle without significant deviations. With age, all clinical indicators naturally gradually decreased. Normal physiological processes in the animal body are confirmed by the results of blood serum analysis: the number of erythrocytes (6–8 million/mm^3), hemoglobin (10–13%), leukocytes (6–12 thousand/mm^3), lymphocytes (49–52%). level of glucose and albumins, lipoproteins, carotene, calcium and phosphorus concentration.

The age-related exterior changes were observed. The indicators of all measurements increased naturally (table 2): in comparison with the one-year age, the height in withers at the age of 30 months of the Hereford bulls increased by 14%, the Aberdeen Angus — by 13%, the height in sacrum — by 10 and 13%, respectively, the chest width — by 49 and 34%, chest depth — by 26 and 23%, chest girth — by 25 and 20%, back width in the macklocks — by 45 and 41%, in the hip joint — by 27 and 23%, and in the buttocks humps — by 86 and 62%, back half girth — by 27 and 26%, metacarpus girth — by 19 and 21%, head length — by 13 and 11%, forehead width — by 17 and 16%, oblique body length — by 19 and 12%.

According to all external data, the Aberdeen Angus bulls were smaller compared to the Herefords, but the animals of both breeds were compact with proportional forms of parts of the body, in relation to the ratio of height and depth and body length and width, as a result of which the animal acquired a more rounded barrel-shaped physique with age with a broad back, a well-developed rear third, that is, those parts that give the most valuable meat and in larger quantities [2]. They reached optimal development at the age of 18 months.

Body measurements characterize the meat type. Live weight gain is related to linear, although the latter increases less intensively than the former, which follows from the Darwinian law of the ratio of growth and the correlative relationship between individual parts of the

Table 1. Clinical indicators of bulls

Breed	Age, months	Body *t*, C°		Pulse per min		Breaths per min	
		M	lim	M	lim	M	lim
H	at birth	40.4	40.3–40.5	125.5	121–130	31.5	31–32
	6	40.3	40.2–40.4	94.5	93–96	29.0	28–30
	12	39.1	38.9–39.8	92.5	91–94	23.5	23–24
	18	38.9	38.7–39.1	84.5	93–86	19.0	18–20
	24	37.9	37.8–38.1	72.5	71–74	18.0	17–19
	30	37.4	37.1–37.6	61.0	60–62	15.5	15–16
AA	at birth	40.2	40.1–40.3	137.0	134–140	30.5	30–31
	6	39.9	39.7–40.1	94.0	93–95	28.0	27–29
	12	39.2	39.0–39.8	83.5	83–84	22.0	21–23
	18	38.5	38.4–38.6	73.5	71–76	17.0	16–18
	24	38.1	38.0–38.2	63.5	61–66	16.0	15–17
	30	37.5	37.4–37.6	62.5	60–64	14.5	13–16

Note. Here and in the next tables H — Hereford, AA — Aberdeen Angus.

Table 2. Age-related exterior changes, cm (X±Sx)

Body measurements	Breed	Age, months			
		12	18	24	30
Oblique body length	H	143.8± ±2.61	157,6 ±3,91	166,0± ±2,33	171,7± ±1,54
	AA	130.0± ±1.17	134,5± ±0,74	138,7± ±0,54	145,6± ±1,32
Height in withers	H	107.2± ±0.42	115,6± ±0,70	120,0± ±0,52	121,0± ±1,01
	AA	99.6± ±0.64	102,8± ±1,61	110,7± ±0,92	112,9± ±1,04
Height in sacrum	H	110,0± ±0.91	121,4± ±1,62	123,4± ±1,14	124,0± ±3,61
	AA	103.5± ±0.86	108,9± ±0,59	115,7± ±0,59	117,9± ±0,72
Chest depth	H	56.2± ±0.41	65,6± ±1,84	69,4± ±0,95	70,7± ±1,32
	AA	52.0± ±0.24	56,3± ±0,81	61,0± ±0,69	63,9± ±1,24
Chest width	H	38,8± ±0.22	46,4± ±0,81	55,0± ±0,66	57,7± ±0,34
	AA	35.8± ±0.81	40,0± ±0,66	44,7± ±0,71	47,9± ±0,49
Chest girth	H	170.2± ±1.81	194,6± ±3,67	208,0± ±1,72	212,7± ±0,39
	AA	143.6± ±1.04	151,8± ±1,12	162,0± ±0,94	167,9± ±0,88
Back width in macklocks	H	39.6± ±0.84	47,4± ±0,82	49,2± ±0,73	49,3± ±0,38
	AA	33.9± ±0.35	35,3± ±0,24	41,7± ±0,59	47,9± ±0,61
Back width in the hip joint	H	40.0± ±0.71	47,5± ±1,03	49,9± ±0,79	50,6± ±0,34
	AA	40.2± ±0.69	44,3± ±0,43	48,7± ±0,38	49,9± ±0,37
Back width in the buttock humps	H	13.4± ±0.54	17,8± ±0,60	23,4± ±0,48	25,0± ±0,69
	AA	11.7± ±0.15	12,3± ±0,16	14,3± ±0,29	19,1± ±0,77
Back half girth	H	94.1± ±1.44	97,3± ±1,53	117,4± ±1,21	119,1± ±1,17
	AA	92.8± ±1.31	95,5± ±1,67	115,3± ±1,17	116,9± ±1,21
Metacarpus girth	H	19.4± ±0.41	22,2± ±0,24	22,4± ±0,29	23,0± ±0,09
	AA	16.0± ±0.23	16,6± ±0,27	18,5± ±0,29	19,4± ±0,08
Head length	H	40.0± ±1.05	42,4± ±0,90	45,0± ±0,37	45,2± ±0,34
	AA	39.0± ±0.44	34,8± ±0,66	43,0± ±0,33	43,1± ±0,29
Forehead width	H	21.2± ±0.61	22,6± ±0,77	24,6± ±0,26	24,7± ±0,31
	AA	19.2± ±0.41	19,3± ±0,31	21,0± ±0,33	22,4± ±0,17

animal's body, which consists in the fact that the entire organization of the animal during growth and development to be in such a relationship that when changes occur in any part and are accumulated by natural selection, other parts also change. Our research confirms the opinion of N. G. Chervinskyi and A. A. Moliganov, that in young animals the live weight increases more slowly compared to the growth of the body in width and length. Body composition indexes more objectively characterize the degree and process of growth and development of individual parts of the body and the organism in general (table 3).

With age, the stretching, pelvic-thoracic, thoracic, bonyness, and compactness indices increase, while long-leggedness decreases. In all age periods, the animals had a compact body structure, a deep and wide body, a well-developed chest, a well-filled rear third of the body, which are characteristic of animals with a strong constitution and potentially high meat productivity.

Some interbreed differences were observed in the energy of growth in bulls in separate age periods (table 4). The highest average daily increases were in the sucking period. In the future, they gradually decreased. But during the entire period of research, they remained high. However, Herefords grew more intensively, as evidenced by absolute increases. Weight growth occurred in parallel with linear growth, but the latter increased more slowly than the former. This corresponds to the Darwinian law of individual development — the ratio of growth and correlative connection between individual parts of the body of animals, which is also confirmed by body composition indices.

In connection with the fact that the average daily and therefore the absolute gains of Aberdeen Angus in all age periods were lower than those of Hereford cattle, they were inferior to Herefords in terms of live weight (table 5). The relative growth rate in animals of both breeds in all studied periods was practically the same — 19–22%. The lower rate of increase in live weight of Aberdeen Angus has a negative impact on the efficiency of using feed because animals use more nutrients in the diet to obtain a unit of fat, including crude, than to produce muscle tissue (meat).

The results of our research correspond the statement of many scientists that the absolute increase in the body weight of animals increases intensively until it reaches 1/3 of the weight of the grown animal, and then decreases [16]. These indicators are important from a practical point of view, and the relative growth rate (multiplicity) indicates the intensity of growth and the intensity of assimilation processes in the body [3]. It is also important for assessing the genetic potential of productivity and the economic and biological characteristics of the breed.

The level of meat productivity depends on the conditions of animal feeding [6]. As for feed costs for live weight gain, they increased with age, especially after 18 months of life, which is associated with faster growth rates of adipose tissue compared to muscle tissue (table 6). This is characteristic of precocious specialized breeds with intensive formation of beef marbling. Each kilogram of fat increases the total feed consumption [9].

Table 3. Body structure indices in bulls

Indicator	Breed	Age, months			
		12	18	24	30
Long-leggedness	H	47.8	45.2	44.9	43.8
	AA	47.5	43.2	42.1	36.9
Stretching	H	120.5	122.4	124.9	125.8
	AA	119.5	124.2	126.3	127.2
Pelvic-thoracic index	H	105.6	113.3	117.2	119.4
	AA	97.6	98.8	111.7	116.9
Thoracic index	H	68.8	71.5	73.3	78.8
	AA	69.0	70.7	79.2	81.7
Compactness	H	119.6	120.7	124.5	129.9
	AA	132.7	135.5	137.7	140.0
Macklocks/hip joint index	H	26.1	27.8	29.4	31.4
	AA	33.5	37.5	42.0	46.0
Bonyness	H	16.1	16.2	16.7	16.8
	AA	18.2	19.2	19.6	19.9
Latitude	H	30.9	31.8	32.8	33.1
	AA	29.0	30.2	34.0	36.0

Table 4. Gain in bulls of experimental breeds

Age period, months	Daily average, g		Absolute, kg, X±Sx	
	H	AA	H	AA
0–6	1191	901	215.5±1.12	162.2±1.64
6–12	1008	882	126.0±2.91	68.8±1.87
0–12	936	707	341.5±3.74	127.2±2.89
12–18	875	676	157.5±4.64	103.7±5.19
0–18	924	620	499.0±6.99	334.7±5.91
18–24	853	626	81.5±7.81	112.6±6.47
0–24	795	612	580.5±8,96	447.3±7.72
24–30	661	534	83.0±9.11	60.2±8.37
0–30	730	558	663.5±11.04	507.5±9.85

Table 5. Dynamics of live weight in bulls, kg (X±Sx)

Age, months	Breeds	
	H	AA
At birth	25.0±0.50	23.5±0.58
6	240.5±3.85	185.7±4.11
12	366.5±5.70	254.5±4.34
18	524.0±7.90	358.2±6.19
24	606.5±8.25	470.8±7.71
30	688.5±9.50	531.0±8.67

Table 6. Feed costs per 1 kg of growth, MJ (X±Sx)

Age, months	Breeds	
	H	AA
0–6	132.4±1.17	135.1±1.24
6–12	112.7±1.14	113.4±1.27
12–18	91.2±0.98	96.2±1.06
18–24	119.6±1.16	125.4±1.24
24–30	148.4±2.67	153.6±2.78
0–30	117.2±1.24	121.3±1.31

Thus, the potential of rocks even in the difficult ecological and climatic conditions of the Ukrainian steppe is great. Therefore, it is short-sighted to abandon the use of Herefords and Aberdeen Angus, both in the creation of purebred herds and in industrial crossbreeding.

Table 7. Slaughter rates of bulls (X±Sx)

Indicator	Age, months	Breeds	
		H	AA
Pre-slaughter live weight, kg	18	508.4±6.77	340.1±4.27
	24	583.0±10.64	447.01±8.90
	30	688.2±14.72	504.3±12.31
Steamed carcass weight, kg	18	312.7±12.52	202.9±6.05
	24	363.0±14.10	259.2±4.46
	30	416.1±16.3	294.0±9.64
Steam carcass output, %	18	61.4±0.41	59.8±1.35
	24	62.2±0.63	57.9±0.40
	30	62.3±0.37	58.3±0.09
Specific weight of the high category offal, %	18	86.4±0.83	85.7±0.77
	24	84.9±0.74	83.2±0.81
	30	85.5±0.57	82.8±0.64
Crude fat weight, kg	18	5.7±0.10	6.8±0.14
	24	18.9±0.24	13.9±0.31
	30	23.0±0.39	17.0±0.44
Crude fat output, %	18	1.1±0.12	2.0±0.94
	24	3.7±0.18	4.1±1.12
	30	4.6±1.41	5.0±2.17
Slaughter yield, %	18	64.6±0.30	61.4±0.90
	24	65.5±0.42	61.1±0.31
	30	65.7±0.24	61.9±0.34

Table 8. Morphological composition of carcasses (X±Sx)

Indicator	Age, months	Breeds	
		H	AA
Muscle weight, kg	18	239.2±3.12	163.4±3.77
	24	284.3±3.01	209.4±2.99
	30	328.9±2.92	244.9±2.70
Muscle yield, %	18	76.5±2.02	80.5±1.19
	24	78.3±2.14	80.8±1.76
	30	79.1±3.01	83.3±2.04
Bone weight, kg	18	42.4±1.14	35.6±1.41
	24	54.6±1.87	42.9±1.58
	30	60.2±2.94	47.4±3.06
Meatiness index	18	5.6±0.11	4.6±0.17
	24	5.2±0.19	4.9±0.24
	30	5.4±0.32	5.2±0.39
The specific weight of the high quality meat, %	18	12.3±0.79	8.5±0.66
	24	12.6±0.86	8.7±0.83
	30	12.7±0.97	8.8±0.84

Table 9. Characteristics of crude fat (X±Sx)

Indicator	Age, months	Breeds	
		H	AA
Crude fat weight, kg	18	15.9±0.6	6.9±0.8
	24	18.9±2.01	13.9±0.3
	30	23.1±2.03	17.0±1.8
Including: gastric, kg	18	4.9±0.17	2.6±0.32
	24	8.9±1.19	3.1±0.96
	30	9.7±1.31	5.9±1.04
kidney, kg	18	7.4±0.82	2.2±0.66
	24	8.3±1.09	6.9±0.93
	30	8.6±1.22	7.3±1.12
intestinal, kg	18	3.5±0.31	3.1±0.12
	24	4.2±0.40	3.2±0.87
	30	4.9±0.52	3.5±0.91
heart, kg	18	0.1±0.01	0.2±0.01
	24	0.5±0.10	0.7±0.12
	30	0.9±0.24	0.7±0.21
Output of crude fat	18	5.1±0.47	3.5±0.24
	24	5.2±0.49	5.4±0.62
	30	5.6±0.54	5.8±0.73

The Hereford bulls breed by habitus and live weight were larger and heavier than Aberdeen Angus ones. Despite this, the animals of both breeds in the end of the experiment reached high weight conditions, which had a positive impact on slaughter indicatiors (table 7).

The majority of scientists were limited to raising livestock up to 15, 18, and 21 months of age [10]. We believe that such age periods are not typical for all meat breeds, due to the great difference in the results of their slaughter. Therefore, we conducted a study when the animals were slaughtered at a later age.

One of the main indicators of the nutritional value of beef is the weight of the carcass and its morphological composition and ratio of individual parts, yield of offal and crude fat (table 8). The carcasses of experimental animals in all controlled periods are classified as I category.

With the age of the animals, the weight of the paired carcass, crude fat, and therefore the slaughter weight and the slaughter yield, increased, except for the yield of high categoty offal. During the entire period of research, Hereford bulls were ahead of their Aberdeen Angus peers. The morphological composition of carcasses shows that precocious British breeds show the greatest intensity of growth in live weight and carcass weight up to 18 months of age, and later — fat weight (table 9). It is desirable to take this pattern into account when deciding on the duration of their cultivation and implementation, because the synthesis of each extra kilogram of crude fat, which, like subcutaneous fat (watering), is not in demand by the consumer, and the body spends much more feed than on production of muscles [1]. Age-related changes also occur in the chemical composition of fat. This is especially visible when comparing breeds — Herefords accumulate more raw material.

In adults, the function of individual organs and metabolism decreases, as a result of which the intensity of fat deposition in different parts of the body is not uniform. First, it accumulates on the internal organs, then between the muscles and under the skin, and at the end of fattening — in the muscles (the meat acquires marbling). Fat synthesis increases from the moment when the caloric content of the diet begins to exceed the body's energy expenditure. Ability to early obesity is one of the signs of precociousness of livestock [11].

Fat is evenly distributed between muscles, which makes them "marble" and increases the taste of beef [6]. Out of the total amount of fat in the body of bulls, the share of fat in the carcass was 29%, and fat in raw meat was 71%. In their further cultivation, the amount of fat in the carcass increased to 55% (table 10). The chemical composition changed with age — less moisture, more protein and especially fat. The ratio of muscle components becomes more attractive to the consumer [8]. The presence of fat in the meat makes it juicy, tender and aromatic. But excess fat impairs the body's assimilation of nutrients and the culinary qualities of beef. The total weight of crude fat increases dynamically from 15–18 months of age. Gastric and cardiac had the highest growth rates, and intestinal occurred at a slower rate [7].

Table 10. Chemical composition of muscles, % (X±Sx)

Indicator	Age, months	Breeds	
		H	AA
Water	18	60.9±2.83	63.6±2.17
	24	57.3±1.81	59.4±1.77
	30	54.1±0.56	55.7±0.61
Protein	18	16.9±0.39	16.1±0.57
	24	16.2±1.61	15.9±1.72
	30	15.6±1.14	15.4±1.66
Fat	18	21.2±2.24	22.1±1.98
	24	24.5±2.57	25.7±2.19
	30	29.3±1.19	30.2±2.14
Fat:water ratio	18	34.8±1.71	34.7±1.98
	24	42.3±2.49	43.2±2.86
	30	54.2±3.92	54.2±4.17
Protein:fat ratio	18	0.8±0.04	0.7±0.05
	24	0.7±0.03	0.6±0.05
	30	0.5±0.05	0.5±0.06
Caloric content in 1 kg of muscles, MJ	18	11.15±0.969	12.1±0.886
	24	12.49±1.149	13.2±1.219
	30	14.08±2.041	15.1±2.140

There was no clear regularity of the yield of offal. But with the age of the animals there was a trend of an absolute increase in the weight of the most nutritionally valuable offal, while their relative and specific weight decreased (table 11).

The absolute weight of the stomach and its components consistently increased with the age of the animals (table 12). When studying the ratio of the weight of the stomach and its departments with the pre-slaughter live weight, the same pattern was revealed. In Hereford bulls, the development of the stomach was generally completed by 18 months, in Aberdeen Angus — by 20 months.

In accordance with the general biological laws of individual development of cattle, the relative weight of the stomach and rumen increased throughout the period of research, and the rumen, reticulum and abomasum — only up to 18 months of the animals' life. This also applies to the intestines.

Structural transformations of the rumen, reticulum and omasum occur after the 3rd month of age, which is associated with a change in the type of feeding, when the abomasum reduces its function in connection with the transition from the dairy period of nutrition to vegetable feed. It also contributed to the development of the intestines. We did not find a clear dependence of its length on the age of the bulls (table 13). But there was a tendency to decrease the length of the small intestine and increase the length of the large intestine.

Undoubtedly, the size and function of the small and large intestines was affected by the type of livestock feeding, namely, the total weight and specific weight of coarse-fiber feed was increased in the rations — straw of winter and spring crops, silage not only from corn of milk-wax maturity, but also of full grain maturity (so-called "yellow silage") and silage from dried alfalfa, meadow hay and sown cereal and leguminous grasses, mineral feed and feed additives, food industry waste from food grain processing. A similar effect on the development of the gastrointestinal tract was provided by a change in the regime of livestock feeding, the sequence of feeding the ration of fodder, taking into account their nutritional and palatable qualities of forage.

Table 11. Weight and yield of offal (X±Sx)

Offal	Age, months	Breeds			
		H		AA	
		weight, kg,	output, %	weight, kg,	output, %
I category, total	18	16.9±1.11	3.3	10.7±0.97	2.1
	24	20.9±3.42	3.6	11.4±1.14	2.5
	30	20.2±3.50	3.0	14.1±2.71	2.8
including: liver	18	6.0±0.4	1.2	5.3±0.81	1.5
	24	6.3±0.2	1.1	5.6±0.93	1.3
	30	7.7±1.1	1.2	6.9±0.90	1.4
kidneys	18	0.9±0.02	0.2	0.7±0.01	0.2
	24	1.0±0.03	0.2	0.8±0.01	0.2
	30	1.2±0.05	0.3	0.9±0.04	0.2
heart	18	1.5±0.10	0.3	0.7±0.10	0.5
	24	2.0±0.02	0.3	1.8±0.20	0.4
	30	2.3±0.10	0.3	1.9±0.20	0.4
tongue	18	1.2±0.09	0.2	0.7±0.8	0.2
	24	1.2±1.00	0.2	0.8±0.7	0.2
	30	1.4±1.10	0.2	1.0±0.9	0.2
brain	18	0.9±0.05	0.2	0.8±0.05	0.1
	24	1.0±0.08	0.2	0.9±0.07	0.2
	30	1.5±0.11	0.2	1.3±0.08	0.2
II category, total	18	35.0±2.71	6.8	31.7±2.14	9.3
	24	45.3±4.18	7.8	37.2±3.42	8.3
	30	49.7±5.21	7.0	38.9±4.17	7.7
including: trachea	18	3.4±1.00	0.7	2.9±0.5	0.9
	24	3.8±0.79	0.7	4.1±1.0	0.9
	30	4.1±0.3	0.6	4.4±1.1	0.9
lungs	18	3.8±0.51	0.8	4.1±0.4	0.9
	24	6.0±0.80	1.0	5.6±0.3	1.2
	30	6.8±0.10	0.7	6.1±0.2	1.2
spleen	18	0.9±0.10	0.2	0.6±0.1	0.2
	24	0.9±0.10	0.2	0.7±0.2	0.2
	30	0.9±0.10	0.1	0.8±0.1	0.2

Table 12. Development of the stomach of bulls, kg (X±Sx)

Indicator	Age, months	Breeds	
		H	AA
Stomach weight, total, kg	18	16.5±2.12	12.9±0.32
	24	17.7±2.43	15.0±0.44
	30	21.8±2.81	18.4±1.17
including: rumen	18	10.0±0.83	6.7±0.52
	24	10.1±0.86	6.9±0.98
	30	10.2±0.94	8.9±1.24
reticulum	18	1.0±0.33	0.7±0.12
	24	1.2±0.37	0.8±0.26
	30	1.7±0.39	0.9±0.19
abomasum	18	2.1±0.07	1.2±0.17
	24	1.6±0.19	1.6±0.21
	30	2.1±0.15	1.7±0.19
omasum	18	2.1±0.03	4.3±0.16
	24	6.0±0.20	5.7±0.19
	30	7.8±1.2	6.9±0.20

Table 13. Weight and length of intestines of cattle (X±Sx)

Indicator	Age, months	Breeds	
		H	AA
Intestine weight, total, kg	18	6.5±0.42	6.0±0.24
	24	9.7±0.89	6.8±0.51
	30	10.2±0.21	7.2±0.19
including: small intestine, kg	18	2.3±0.10	2.4±0.11
	24	3.4±0.43	2.9±0.40
	30	3.6±0.72	3.1±0.53
colon, kg	18	3.3±0.19	2.6±0.22
	24	5.3±0.42	2.7±0.13
	30	5.4±0.71	2.8±0.51
cecum, kg	18	0.9±0.04	1.0±0.10
	24	1.0±0.01	1.2±0.11
	30	1.2±0.06	1.3±0.50
The intestine length, total, m	18	43.7±1.39	38.4±0.41
	24	45.6±1.61	41.2±0.29
	30	46.8±0.50	42.1±0.40
including: small intestine, m	18	35.4±1.32	33.0±0.80
	24	35.7±1.61	34.4±1.12
	30	36.7±1.55	35.0±1.42
colon, m	18	6.8±0.54	4.1±0.21
	24	8.3±0.63	5.5±0.33
	30	8.4±0.29	5.7±0.90
cecum, kg	18	1.5±0.09	1.0±0.14
	24	1.6±0.01	1.3±0.11
	30	1.7±0.06	1.4±0.12
Ratio of the whole intestine weight to the live weight, %	18	1.28	1.76
	24	1.67	1.62
	30	1.50	1.43

The condition of the bones, the specific weight of which decreased by 1.5 times over the course of the research with age, while the absolute weight and size increased by two times, their strength by three times, also testifies to the good adaptation of the experimental cattle to the ecological, climatic and fodder conditions of the steppe of Ukraine. This was influenced by the amount of calcium and phosphorus in them, the indicators of which are higher in Hereford than in Aberdeen Angus and the bone walls were thicker (table 14). The mineral state of the bones of both breeds is optimal for realization and high meat productivity.

The marketable properties of the skins of bulls of both breeds already at the age of one year met the requirements of the leather industry for raw materials: heavy (categorized as bull — more than 25 kg), high yield, long, wide, large area, Herefords are relatively thicker.

All these indicators naturally increase with age, as well as the habit of the animals — in the subsequent period of slaughter, they exceeded the weight of the skin of the animals in the previous one (table 15). A similar trend took place in relation to their length, width and area. The chemical composition remained practically stable during the entire period of research.

The quality of the meat of bulls in all studied age periods had high physical and technological properties and was suitable for culinary use and long-term storage (table 16). One of the criteria that determines the completion of growing young animals is the meat maturity indicator — the ratio between fat and moisture [4].

Table 14. Mineral composition of bulls' bones, % (X±Sx)

Indicator	Age, months	Breeds			
		H		AA	
		humerus	metacarpal	humerus	metacarpal
Calcium	18	23.8±±0.51	32.4±±0.32	22.9±±0.51	30.8±±0.29
	24	28.6±±0.23	38.3±±0.60	25.4±±0.47	35.4±±0.69
	30	28.3±±0.60	39.7±±0.84	26.7±±0.63	37.1±±0.78
Phosphorus	18	12.3±±0.22	11.9±±0.31	11.8±±0.19	10.7±±0.27
	24	12.4±±0.30	12.0±±0.24	11.9±±0.34	11.5±±0.30
	30	12.1±±0.34	12.7±±0.23	12.2±±0.29	12.1±±0.26
Potassium	18	0.04±±0.011	0.04±±0.011	0.04±±0.012	0.03±±0.007
	24	0.04±±0,015	0.05±±0.009	0.03±±0.010	0.03±±0.009
	30	0.03±±0.011	0.05±±0.021	0.03±±0.014	0.04±±0.010
Sodium	18	0.9±±0.08	0.6±±0.07	0.7±±0.02	0.6±±0.01
	24	0.8±±0.08	0.8±±0.02	0.7±±0.02	0.9±±0.01
	30	0.8±±0.09	0.7±±0.07	0.6±±0.01	0.8±±0.02
Magnesium	18	1.8±±0.14	1.4±±0.12	1.7±±0.14	1.5±±0.11
	24	1.7±±0.10	1.6±±0.17	1.7±±0.16	1.7±±0.16
	30	1.7±±0.12	1.7±±0.09	1.6±±0.12	1.6±±0.13
Crushing force, kg/cm^2	18	2067±±33	2500±±109	1921±±49	2341±±98
	24	3001±±52	5939±±153	5217±±74	5016±±144
	30	5667±±88	5067±±233	4839±±82	5421±±169

More than 30 animals older than 18 months indicates a high fat content of beef and the expediency of their slaughter. But even at the age of 30 months, the quality of the meat remains high. Precociousness of animals also determines the ratio between dry matter and moisture. In our study, it was in the range of 0.56–0.60 in both breeds in the conditions of the steppe of Ukraine.

The beef quality is also determined by the ratio between protein and fat. 0.5–1:1 is considered normal. The growth of fat increased the calorie content of meat, which is age-dependent [5, 13].

Hereford and Aberdeen Angus breeds bulls are able to show high productivity in the ecological, climatic and fodder conditions of the steppe of Ukraine under pasture-free cultivation for up to 2.5 years and reach 688 and 531 kg of live weight, respectively, at the end of fattening, with a harmonious body and perfectly expressed m in clear forms. Therefore, they should occupy a worthy place in the structure of meat cattle breeding of the state and contribute to the increase in the production of high-quality marble beef.

Table 15. Quality of steamed skin (X±Sx)

Indicator	Age, months	Breeds	
		H	AA
Weight, kg	18	55.3±3.52	40.4±1.14
	24	60.7±1.27	43.0±5.72
	30	63.7±2.91	48.0±5.21
Output, %	18	10.2±0.54	11.9±0.4
	24	10.7±1.81	9.6±1.5
	30	10.9±2.79	9.5±2.4
Length, cm	18	198.3±9.17	197.3±0.18
	24	216.3±10.42	215.0±0.14
	30	226.7±10.61	219.0±0.23
Width, cm	18	185.7±2.76	186.5±0.12
	24	223.0±3.45	190.0±0.19
	30	226.4±5.14	196.0±0.31
Area, cm^2	18	362.1±9.54	368.4±1.11
	24	482.3±11.73	409.0±2.63
	30	489.7±12.12	411.6±3.71
Thickness near the last rib, mm	18	5.6±0.20	4.3±0.8
	24	6.2±0.73	6.8±2.12
	30	8.4±1.37	6.5±2.71

Table 16. Meat quality (X±Sx)

Indicator	Age, months	Breeds	
		H	AA
Protein weight in the carcass, kg	18	40.4±1.23	39.1±1.4
	24	48.9±1.27	40.4±1.50
	30	54.3±2.32	50.9±2.12
Fat weight in the carcass, kg	18	50.7±2.17	61.7±4.13
	24	69.6±3.27	72.1±6.18
	30	96.4±6.11	114.4±8.12
Protein qualitative indicator	18	4.49±0.002	4.32±0.001
	24	4.32±0.002	4.24±0.02
	30	4.30±0.004	4.03±0.05
Protein:fat ratio, %	18	0.8±0.01	0.6±0.01
	24	0.7±0.03	0.5±0,01
	30	0.5±0.02	0.4±0.02
Meat marbling, %	18	21.2±1.41	22.7±1.38
	24	24.9±1.60	26.4±1.54
	30	29.2±2.02	31.2±2.07
Calorie content of 1 kg of meat, MJ	18	11.2±1.04	12.9±1.09
	24	12.5±1.15	14.7±1.29
	30	14.1±1.34	18.1±1.47
Tenderness of meat, g/cm/sec	18	0.544±0.0061	0.498±0.0052
	24	0.679±0.0074	0.689±0.0069
	30	0.718±0.0081	0.701±0.0074

Dynamic age-related changes in the live weight of animals caused changes in linear external measurements, indexes of a compact physique with a developed deep chest, a full rear part of the body, which are characteristic of cattle with a strong constitution and potentially high meat productivity. The relative growth rate of experimental bulls during the study was within 19–22% and did not exceed 1.2–1.3 times the live weight of the previous period.

In comparison, Herefords differ from Aberdeen Angus bulls in a somewhat larger habitat, massiveness, growth energy, feed conversion, slaughter performance, balanced morphological composition of carcasses, meatiness ratio, heavy fatless offal and skin with a thin layer of irrigation.

It is more expedient to hold animals of the researched breeds up to 18–24 months, but today, when their number is small, and reproduction requires a certain amount of time and money, we believe that it is possible to extend the period of growing the relevant livestock up to 30 months. At the same time, the quality of beef and broth practically does not change with age and it is 4.5 points.

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Комплексна оцінка бугаїв скоростиглих м'ясних порід англійської селекції в умовах України

В. С. Козир
izkzoo3337@gmail.com

Інститут зернових культур НААН, вул. Володимира Вернадського, 14, м. Дніпро, 49009, Україна

Проведено інтегровану оцінку продуктивності бугайців скоростиглих м'ясних герефордської і абердин-ангуської порід англійської селекції в умовах степової зони України. Встановлено, що худоба з місцевості приморського клімату пристосувалась до сухого жаркого середовища степової зони, про що свідчать клінічні показники організму тварин. Худоба гармонійно розвивалось, екстер'єрні проміри та індекси тілобудови були в межах породних норм. Бугайці герефордської і абердин-ангуської порід за умов безпасовищного вирощування до 2,5 року при завершенні відгодівлі мали високу продуктивність — 688 і 531 кг маси тіла відповідно, з гармонійно розвинутим тулубом та ідеально вираженими м'ясними формами. Бугайці були компактної тілобудови з розвинутими глибокими грудьми, виповненою задньою частиною тіла, що характерно для худоби з міцною конституцією і потенційно високою м'ясною продуктивністю. Відносна швидкість росту бугайців впродовж дослідження була в межах 19–22%. Тому вони є перспективою м'ясного скотарства України для збільшення виробництва високоякісної «мармурової» яловичини. Герефорди, порівняно з абердин-ангусами, вирізняються дещо більшим габітусом, масивністю, енергією росту, конверсією корму, забійними показниками, збалансованим морфологічним складом туш, коефіцієнтом м'ясності. Абсолютні і відносні прирости маси тіла підтверджують високий генетичний потенціал м'ясної продуктивності: 18–24-місячні бугайці досягли реалізаційних кондицій. На сьогодні їх кількість невелика, а відтворення вимагає певного часу і коштів, тому вважаємо, що термін вирощування поголів'я можна подовжити до 30 місяців. У період становлення галузі м'ясного скотарства можливо вирощувати молодняк до 30-місячного віку без погіршення забійних показників та кулінарних і смакових якостей яловичини відповідно до вимог споживача.

Ключові слова: велика рогата худоба, порода, бугаї, екстер'єр, м'ясна продуктивність, забійні показники, якість яловичини

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