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ARTICLE

# Adaptation of different generations of hereford and aberdeen angus breeds to the ambient temperature of the Northern region of Kazakhstan

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**Abstract:** This article presents the findings of a study examining how Hereford and Aberdeen-Angus breeds are adapting to ambient temperatures in northern Kazakhstan. The study suggests that animals of second and third generations display the highest levels of adaptability to high temperatures in their environment, thus requiring less stress on their protective bodily functions. These groups also exhibit a more sophisticated system of thermoregulation, enabling them to efficiently allocate body resources in hot weather, a common occurrence during the summer months in the northern region of Kazakhstan. These findings contribute to a deeper understanding of the mechanisms involved in breed adaptation to environmental conditions and the findings could be valuable to farmers and breeders in the region seeking to optimize their animal production practices.

**Keywords:** *acclimatization; body heat resistance; cold tolerance; beef cattle breeding; imported breeds;*

## INTRODUCTION

Livestock population in Kazakhstan is growing rapidly due to their import, positively impacting the breeding base and resulting in high-quality produce and pedigree animals. However, it is extremely important to consider factors such as breed suitability for local climatic conditions, appropriate feed, and access to veterinary care, which are crucial when managing import of cattle. High ambient temperatures are the primary factors destabilizing acclimatization in cattle, negatively impacting on their productivity, preservation of homeostasis, and genetically determined productivity and reproductivity. Therefore, this study aims to investigate the heat tolerance index of young animals and heifers from different generations [1,2,3], in the context of minimum productivity and reproductive qualities of imported cattle breeds in the sharply continental climate of northern Kazakhstan's different natural zones [4,5,6].

Despite the growing livestock population, the existing literature suggests that there are not sufficient information on the acclimatization of imported beef cattle breeds in Kazakhstan.

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Acclimatization criteria are not defined, the general theory of acclimatization concerning forage, technological and weather factors of adaptation are not in place, and heat and cold tolerance evaluations for imported breeds are absent. None of the imported cattle breeds are evaluated by heat and cold tolerance, while high ambient temperatures are the main destabilizing factor for acclimatization. Furthermore, minimum productivity and reproductive qualities in the context of breeds in the new weather and climatic conditions of the sharply continental climate of different natural zones in the north of Kazakhstan, where imported cattle breeds are brought and will be imported in the future as well, have not been defined. Our study aims to contribute to filling these knowledge gaps and to providing insights that could enhance breeding practices in Kazakhstan's livestock industry. Materials from previous scientific studies support the need for this research.

This scientific paper aims to establish the criteria for the acclimatization of Aberdeen-Angus and Hereford cattle breeds in the northern region of Kazakhstan, and examine their acclimatization, adaptation, and maternal and productive qualities. The practical significance of this work lies in the investigation of methods for selecting animals based on their optimal parameter of resistance to cold and heat in the new environment of Kazakhstan.

Each species, breed, sex and age of animals have a temperature comfort zone or a zone of thermoneutrality, within which the ambient temperature is most favorable for them. Therefore, the success of beef cattle breeding depends heavily on the ability of imported animals to adapt to new conditions of a specific zone in a particular country.

In this context, the study of the adaptive ability of imported beef cattle breeds to the high and low temperatures of the northern region of Kazakhstan, and the identification of the capabilities of the Aberdeen-Angus and Hereford breeds to have high meat productivity in extreme conditions, are critical issues for consideration in agricultural science. Furthermore, this study aims to evaluate the state of their natural protective forces, which characterize their acclimatization abilities in the new habitat.

## MATERIALS AND METHODS

In this study, we conducted scientific and economic experiments to develop the main criteria for acclimatizating imported Kalmyk beef cattle and their generation by economic and biological traits in the conditions of Kazakhstan from 2015-2022. The scientific research was implemented in two farms of the northern region of Kazakhstan, namely, the LLP "Altyndan" of Akmola and the "Zholdasbay-Agro" farm of North Kazakhstan regions, to study the adaptation of imported Hereford and Aberdeen-Angus cattle to new fodder and climatic conditions, and to determine the economically beneficial qualities of their offspring of different generations.

The object of the study comprised young cows of second and third generations and heifers of first and third generations obtained from full-grown cows of Aberdeen-Angus and Hereford breeds not lower than class I. The selection of animals in experimental and control groups was made based on the principle of analogs, with due consideration of the cattle age, productivity, physiological state, and data of clinical examination. We conducted a comparative analysis of the development of calves and heifers of different generations (I, II, and III) of Aberdeen-Angus and Hereford breeds, accounting for live weight and average daily weight gain of heifers up to 12 months of age during the development periods of 2015-2019 births.

Physiological indicators, such as breathing frequency and depth, the minute volume of pulmonary ventilation by mask method, oxygen consumption by the Douglas-Holden method [6], and intensity of sweating by calcium chloride absorption were also determined. To assess heat resistance, we used the heat resistance index by Yu.A. Rauschenbach [7]. This method was developed by considering the identified dependences of

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body temperature fluctuations on changes in the environmental temperature. Based on this dependence, we calculated the regression coefficient of body temperature depending on the environmental temperature. This made it possible to determine the body heat tolerance at any ambient temperature above 30°C.

Bottom of form The Body Heat Tolerance Index is calculated by the following formula:

$$BHTI = 2(0.6T2 - 10\Delta T + 26) \quad (1)$$

Where:

- $T_2$ is the maximum temperature of the environment in degrees Celsius
- $\Delta T$ is the difference between the animal's core body temperature and the environment temperature in degrees Celsius

The present study investigated the cold index as part of the budget program "Development of Science" under program 102 "Grant financing of scientific research". The research project entitled "Adaptation and quality of productivity of the third generation of imported beef cattle in the northern region of Kazakhstan" (state registration number 0118RK00736) developed a formula for the cold index, resulting in the issuance of a patent (number 34735) to the project manager and executors. The cold index was determined and evaluated within the scope of the research. [8]

$$Ka=Td: 39.1 + RR: 31 + HR: 84/2.3 \quad (2)$$

Where:

- Ka – adaptation coefficient (at sub-zero temperatures);
- Td – body temperature of the test animal (degrees Celsius);
- 39.1 – body temperature of the animal in normal conditions (degrees Celsius);
- RR – the respiratory rate of the test animal per minute;
- 31 – the normal respiratory rate of the animal per minute;
- HR – heart rate of the experimental animal;
- 84 – the normal heart rate of the animal.

The adaptation coefficient was determined using the R. Beneser formula:

$$KA = RT: 38.33 + RR: 23\ 2.4 \quad (3)$$

Where:

- KA - adaptation coefficient;
- RT – the rectal temperature of the experimental animal;
- 38.33 - the normal body temperature of the animal;
- RR – the respiratory rate of the experimental animal in breaths per minute;
- 23 – the normal respiratory rate of the animal in breaths per minute.

The obtained results and data of zootechnical and breeding accounting were processed using the biometric analysis method (P.F. Rokitsky, 1961, N.A. Plokhinsky, 1970, E.A. Merkuryeva, 1977, O.Yu. Rebrova, 2002) with the use of software tools such as Microsoft Excel 2010, etc [9]

## RESULTS AND DISCUSSION

An important indicator of the animal's vital activity during changes in habitat is the frequency of breathing, heart rate, and body temperature, which are indicators of the relative norm of vital functions. Since the Northern region of Kazakhstan is characterized by high variability of climatic conditions throughout the year compared to exporting regions, we separately studied the above indicators in the obtained heifers of the first and second generations in different seasons of the year (Table 1). The dynamics of breathing frequency turned out to be directly opposite to the dynamics of body temperature: with a decrease in body temperature, the number of respiratory movements increased and vice versa[10,11].

Against the background of intergenerational fluctuations (differences) ($P \leq 0.05$-$0.001$), certain dynamics of body temperature were revealed in different seasons of the year, which varied among the experimental animals from 37.5°C. This indicator changed to a lesser extent in Aberdeen Angus heifers (fluctuations from 37.6 to 38.7°C), while in their Hereford counterparts, fluctuations in body temperature reached 0.4-

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0.6°C and varied from 37.5 to 38.9°C. However, these fluctuations are within the physiological norm. All experimental heifers of the first and second generations were characterized by a decrease in temperature in summer (38.4-38.6°C) and an increase in the autumn (38.7-38.9°C). The increase in respiratory movements in cattle in summer in the conditions of the region, when the ambient temperature often stays at +30-+33°C, is physiologically justified and can be considered a manifestation of adaptive reactions to the climate, in which the removal of excess heat in the summer period is systematically necessary.

***Table 1. Physiological indicators of heifers of first and second generations in different seasons of the year, (n=30)***

| Indicators | Hereford I | Hereford II | Aberdeen-Angus I | Aberdeen-Angus II |
|---|---|---|---|---|
| Winter (-22°C) | | | | |
| Body temperature, °C | 39.0 ± 0.3 | 37.5±0.3 | 39.2 ± 0.2 | 37.6±0.2 |
| Heart rate, beats per minute | 25.21± 0.5 | 74.2±0.3 | 74.5 ± 0.4 | 73.7±0.3 |
| Respiratory rate, times/min | 2.11± 0.3 | 27.5±0.5 | 2.07± 0.6 | 27.3±0.4 |
| Spring (+10 °C) | | | | |
| Body temperature, °C | 38.92 ± 0.3 | 38.9±0.3 | 38.7 ± 0.2 | 38.7±0.2 |
| Heart rate, beats per minute | 74.83 ± 0.4 | 71.7±0.5 | 74.5 ± 0.4 | 71.6±0.5 |
| Respiratory rate, times/min | 2.08 | 24.8±0.4 | 2.07±0.3 | 24.5±0.4 |
| Summer(+27 °C) | | | | |
| Body temperature, °C | 38.42 ± 0.2 | 38.4±0.2 | 38.6 ± 0.1 | 38.6±0.10 |
| Heart rate, beats per minute | 76.13 ± 0.3 | 69.6±0.3 | 75.3 ± 0.3 | 70.4±0.3 |
| Respiratory rate, times/min | 2.13± 0.3 | 26.1±0.3 | 2.14± 0.4 | 26.3±0.3 |
| Autumn (-12 °C) | | | | |
| Body temperature, °C | 38.93 ± 0.3 | 38.9±0.3 | 38.7 ± 0.1 | 38.7±0.1 |
| Heart rate, beats per minute | 73.15 ± 0.3 | 64.8±0.4 | 22.8 ± 0.3 | 64.7±0.3 |
| Respiratory rate, times/min | 2.01± 0.5 | 23.1±0.3 | 2.0± 0.4 | 22.8±0.3 |

The results of this active process likely led to a slight decrease in body temperature during the summer by 0.1-0.4°C. However, the temperature decrease is less pronounced in Aberdeen-Angus calves (from 38.7°C to 38.6°C) compared to their Hereford breed peers (from 38.9°C to 38.5°C), which may be due to lower body weight.

High environmental temperatures are the primary destabilizing factor in acclimatization. This is because high temperatures have an extremely negative effect on meat and milk productivity, homeostasis maintenance, and genetically determined productivity and reproductive capacity. Therefore, we studied the thermotolerance levels in the second-generation heifers'. To assess thermotolerance, we used the thermotolerance index by Yu.A. Raushenbah (Table 2).

***Table 2. Heat resistance index of Aberdeen-Angus and Hereford heifers under conditions of Northern Kazakhstan (n=30)***

| Generation | Body temperature in the morning, °C (at air tempera-ture 22 °C) | Body temperature in the afternoon,°C (at air tempera-ture 31 °C) | Difference between morning and afternoon body temperature,°C | Index of heatresistance |
|---|---|---|---|---|
| Hereford | | | | |
| I | 38.33±0.33 | 39.38±0.18 | 1.05±0.38 | 76.4±4.70 |
| II | 38.36±0.28 | 39.34±0.25 | 0.98±0.31 | 78.0±6.25 |
| Aberdeen-Angus | | | | |
| I | 38.39±0.35 | 39.36±0.17 | 0.97±0.39 | 71.1 ±7.54 |
| II | 38.43±0.25 | 39.38±0.32 | 0.95±0.41 | 70.2±3.14 |

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In animal husbandry, the Road method or the so-called Aberian sample method, has become widely used for evaluating animal heat resistance based on the deviation of body temperature from the norm. Another method for assessing heat resistance was proposed by Y.R. Raushenbach, which is based on the dependence of changes in body temperature on changes in the external environment. The heat resistance index is calculated based on the data of a two-time determination of the animal's body temperature in the morning hours (at a temperature of +100...+150) and in the daytime (at a temperature of +250 and above).

The highest heat resistance index was observed in the second-generation Hereford heifers, which were significantly (p>0.05) superior to their peers from the first generation. The index values were 76.4 and 78.0, respectively. The Aberdeen-Angus heifer's index values were 71.1 and 70.2 respectively.

In the next stage of the study, the adaptation coefficient was determined according to V. Benesru. On an average, the adaptation coefficient values were distributed as follows, and no statistically significant differences were found between the first and second generations.

Our study also found a high correlation between the heat resistance of imported meat breeds and the average annual temperatures of the regions where they were formed. This is confirmed by comparing the heat and cold resistance indices of breeds established by different researchers with the average annual temperatures of the regions where they were bred. According to our research, the optimal temperature for the first and second generations of Hereford and Aberdeen-Angus breeds in the Akmolinsk and North Kazakhstan regions is within the range of +19-22...+27-31°C. The results of the study are presented in Table 3.

***Table 3. Relationship between heat tolerance of beef cattle and average annual temperatures of their formation regions***

| Breed | Generation | Index of heat-resistance | Average annual temperature of the withdrawal area, oC |
|---|---|---|---|
| Hereford | I | 76.4±4.70 | 8-10 |
| | II | 78.0±6.25 | 8-9 |
| Aberdeen-Angus | I | 71.1 ±7.54 | 8-9 |
| | II | 70.2±3.14 | 7-8 |

From the data in Table 3, it is evident that there is a significant correlation between the heat resistance of breeds and the mean annual temperatures of the climatic zones where they are bred.

The highest heat resistance is observed in the Hereford heifers, followed by the offspring of the second generation Aberdeen Angus breed, imported from different regions. The high correlation between the coefficient of heat resistance of breeds, established using the A.O. Road method, and the mean annual temperatures of the regions where they were formed, is evident from Table 4.

***Table 4.Thermonautral temperature in the breeding area and the coefficient of adaptation of livestock***

| Breed | n | A*-coefficient of adaptability | Average annual temperature of the withdrawal area, oC |
|---|---|---|---|
| Hereford | I | 77.55±4.70* | 8-10 |
| | II | 74.13±3.67 | 8-9 |
| Aberdeen-Angus | I | 76.12±5.20* | 7-8 |
| | II | 75.55±4.10 | 8-10 |

*The formula *A = 100-10 (BT-101.0) was used, where BT is the body temperature of cattle in degrees Fahrenheit after they spend the entire day outdoors at a temperature of 31.2°C in the sun.*

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*Table 5. Breed differences in cold hardiness of beef cattle*

| Breed | Generation | Index of cold resistance | Average annual temperature of the withdrawal area, oC |
|---|---|---|---|
| Hereford | I | 73.15±4.70 | -13 |
| | II | 72.8 ± 0.3 | -16 |
| Aberdeen-Angus | I | 75.1±4.70 | -9 |
| | II | 73.7 ± 0.3 | -11 |

Using this method, Yu.O. Raushenbach calculated the coefficients of cold resistance for different breeds of cattle. The data presented on the average annual temperatures largely confirm the fact that cold resistance, like heat resistance, is largely dependent on the climate in which the breeds were formed (Table 5).

The data presented in Table 5 demonstrate that the highest cold resistance index is observed in Aberdeen Angus heifers bred in average annual temperatures of -9...-11°C, and significantly lower in Hereford cattle. Clear differences in the response to temperature decrease are observed between breeds depending on their ecogenesis.

The optimal temperature for Hereford cattle, which have developed in a temperate climate, is -13-16°C, while for Aberdeen Angus cattle it is -16-23°C. Therefore, Hereford cattle experience an increase in heat production when the air temperature drops below the thermoneutral zone.

For large cattle, the most favorable conditions (thermoneutral zone) occur at the ambient temperature within a certain comfort zone, in which the animal does not experience either heat or cold. When calculating the adaptation coefficient of second-generation heifers, the air temperature within the thermoneutral zone ranged from -4°C to -16°C.

Based on the body temperature, respiratory rate and pulse rate of the second-generation heifers, we were able to determine the organism's adaptation coefficient to cold. Clinical studies of animals were conducted, which is crucial for investigating the adaptive responses of the organism to low air temperatures in the conditions of Northern Kazakhstan.

Respiratory rate is a specific indicator of the physiological state of the respiratory system during adaptation. The activity of the respiratory system was measured by visual observation of the animal's inhalation and exhalation, i.e., by the stream of exhaled air through the nose. Due to technical difficulties in recording heart activity at low temperatures, an ultrasound recording method was used. An ultrasound sensor was placed at a right angle to the surface of the animal's body in the fourth intercostal space in the middle of the lower third of the chest, in the best audibility of the bicuspid valve.

After analyzing the existing literature and research methodologies, we have devised a novel approach to determine the adaptation coefficient of meat breed large horned cattle accurately and efficiently to low ambient temperatures. The technical outcome of this innovation is a methodology that is based on comprehensive investigations and factors in the fundamental functional capacities of the animals' cardiovascular system, including the pulse and breathing rates, as well as specific body temperature indicators under favorable conditions (thermoneutral zone).

The adaptation coefficient is calculated by summing the ratios of the body temperature of calves from the first and second generations to the body temperature in favorable conditions, along with their respiratory and pulse rates per minute under favorable conditions (Table 6)

The results of the study showed that the respiratory rate of calves from the first and second generations varied from 20.1±0.9 to 25.4±1.8 breaths per minute at an air temperature of minus 30°C and below. No significant difference was observed in body temperature. At one year of age, a significant variation was observed in terms of cardiovascular activity.

*Table 6. Evaluation of cold tolerance of Hereford and Aberdeen Angus breeds*

| Age, month | Air temperature, °C | Body temperature, °C | Respiratory rate per minute | Pulserateper minute | Coefficient of adaptability |
|---|---|---|---|---|---|
| | | Hereford | | | |
| I | -30 | 39.4±0.07 | 25.4±1.8 | 78.3±2.7 | 2.74 |
| II | -30 | 38.7±0.04 | 23.7±1.5 | 74.1±2.3 | 2.62 |
| | | Aberdeen-Angus | | | |
| I | -30 | 39.1±0.05 | 23.3±1.2 | 76.8±1.9 | 2.71 |
| II | -30 | 38.4±0.03 | 20.1±0.9 | 70.8±1.7 | 2.51* |

**A five-point scale was used for evaluation, with the highest rating being 1, indicating the most cold-adapted animals.*

This suggests a more rational and functional ability of the heart in the young of the first and second generations adapted to low air temperatures in the conditions of Northern Kazakhstan.

The impact of low air temperature on the respiratory and cardiovascular activity of animals from the second generation at ten months of age indicated a lower degree of adaptation compared to the first generation, whose adaptation coefficient positively decreased from 2.74 to 2.51.

## CONCLUSIONS

Based on the results of our research, it can be concluded that the animals of the first and second generations have the highest rate of adaptation to increased environmental temperatures, requiring less stress on the body's protective mechanisms. These groups of animals have a more sophisticated thermoregulation system, allowing for more rational use of the body's resources in hot weather, which is typical for the summer months in the Northern region of Kazakhstan.

Based on the comparison of the aforementioned data, it can be concluded that the body temperature, respiratory system and cardiac activity indicators of the third-generation young livestock, which were derived from imported Aberdeen Angus meat cattle and which were bred under sub-zero temperatures in the Northern region of Kazakhstan, indicate a moderate level of adaptation of their organisms.

According to our research, the optimal temperature for the Hereford and Aberdeen Angus breeds of the first and second generations in the Akmola and North Kazakhstan regions is within the thermoneutral zone or comfortable temperature range of +19-22...+27-31°C.

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