Pakistan J. Zool., vol. 52(2), pp 767-774, 2020. **DOI**: https://dx.doi.org/10.17582/journal.pjz/20190226160249

Adaptation Traits of Second Generation Aberdeen-Angus and Hereford Heifers in Northern Kazakhstan

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Article Information
Received 26 February 2019
Revised 20 June 2019
Accepted 20 September 2019
Available online12 February 2020

Authors' Contribution
NK and TK conceived and planned the study. DI and SB conducted lab work and drafted the manuscript. ZT did statistical analysis of data. SB revised the manuscript.

Key words
Adaptation, Beef cattle, Productivity, Generation, Physiology, Ethology

ABSTRACT

Changing climate and altered environment can significantly impact the adaptation traits among different animal species. We describe here the rationale and economics of adaptation of Aberdeen Angus and Hereford beef-producing animals brought from Canada and the Netherlands to Northern Kazakhstan. In order to investigate common zootechnic methods, daughters of imported Aberdeen Angus and Hereford cows were grouped at the age of 18-19 months with a live weight of no less than 350 kg. Groups were constituted using the analogue-pairs method and consisted of 30 cattle/group. Observations during the present study showed that the average live weight of Hereford heifers of the second generation at the age 18-22 months was 378.5 and 375.2 kg which was 8.7 and 20.6 kg (2.2-5.4%) higher than that of Aberdeen-Angus herd-mates. Chemical analysis of feedstuff was carried out in Altyndan LLP and AKA whereas physiological and clinical indicators of second-generation heifer calves were within the normal range in various seasons. The highest thermal resistance index was in animals of group I and II groups (76.4 and 78.0, respectively). Under the conditions of Akmola and North-Kazakhstan regions, the thermoneutrality or comfort temperature zone for Hereford and Aberdeen Angus breeds was within the range of +19-2 +27-31ºC. Analysis of ethology of animals showed that all groups had 0.19 functional activity index; as for the other indices, animals of group I and II groups (Hereford heifers) had a comparative advantage, they were more active and spent more time in moving and feed eating. Taken together, different breeds can be acclimatised and adapted to the varying climatic conditions through generations and thus presents practical strategy to secure food for growing population in the country.

INTRODUCTION

Owing to increasing human population and higher food security risks, rearing highly productive animal breeds are inevitable. However, the current cattle breeding plans are unable to fulfil the demands of Kazakhstan population. One of the potential ways to solve this problem is to breed specialized pedigree beef cattle and to generate commercial beef breeds. These may be achieved through crossbreeding of dairy breeds with bulls of beef breeds. It is evident from the history of animal's acclimatization to new ecological conditions that imported animals can successfully live and adopt, however, these can lose their distinctive qualities of productive and biological properties.

In the period from 2011 to 2015, a large quantity of beef cattle has been imported in Kazakhstan from USA, France, Canada, Australia, and other countries. Among 5608 thousand animals imported, 13503 were Aberdeen Angus and 10435 were Herefords of various ages and all were registered in Akmola oblast (Makangali *et al*., 2019; Kineev and Erdenov, 2005; Alpeysov, 2009). With this high number of imported animals, there is an urgent need of the research work by developing scientific grounds for acclimatization of these cattle breeds. Effective acclimatization without affecting the genetic productivity performance of Aberdeen-Angus and Hereford breeds in Northern Kazakhstan will have positive knock on affect food security in the country.

It has been argued previously that Aberdeen Angus and Hereford cattle carry wide acclimatization capabilities, however, upon importation into unusual countries with different climates, they are exposed to environmental

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0030-9923/2020/0002-0767 $ 9.00/0

impact. By virtue of animal adaptation, better the conditions of feeding and housing are, the faster additional body defenses would be developed (Belousov *et al*., 2002; Grigorieva, 2009; Golikov, 1985; Rodionov, 2002).

Studies conducted by Shevkhuzhev *et al*. (2012) have shown that Aberdeen Angus cattle are distinguished by high growth intensity and good quality of beef. Thus, it was proposed that Aberdeen Angus bulls from 8 months of age had live weight of 224.8 kg, and until they were 15 months of age they had the highest daily live weight gains from 973.3 to 1216.9 grams a day. The most live weight gain was registered at the age of 12-13 months of age. The study on adaptive and productive properties of beef cattle has shown that Aberdeen Angus breeds carried the high relative gain, best indices of carcass development, high level of profitability of production as compared to Aubrac breed (Kazhgaliyev *et al*., 2016) in the environmental conditions of the Northern region of Kazakhstan.

Kalashnikov (2003) have reported that the acclimatization of imported animals would never be complete, and its negative consequences can manifest in the following animal generations. Therefore, the study of acclimatization is usually carried out in animals of three consecutive genetic ecological generations. Likewise, in dairy cattle breeding, not all breeds adapt to expectation and keep their productivity. It has been reported that lactation performance and natural resistance of Holstein first calf heifers of own generation in conditions of the sharp-continental climate of northern region of Kazakhstan allowed a conclusion that the process of adaptation of Holstein cattle brought from Canada is cumbersome (Alimzhanov *et al*., 2016).

This study is carried out as part of a "Grant-financed Program" of the Ministry of Education and Science of the Republic of Kazakhstan under budgetary program 217 "Development of Science", subprogram 102 "Grant Financing of Scientific Research", with priority "Development of Intensive Stock Farming", on subject "Adaptability and Productive Properties of third Generation of Imported Beef Cattle in a Climate of the Northern Region of Kazakhstan". The purpose of this study is to assess the economic properties of Aberdeen-Angus and Hereford heifers of second generation in climatic conditions of Northern Kazakhstan.

In the process of adaptation, imported animals can experience stresses; it is therefore imperative to reduce these factors as much as possible so that their descendants are adapted to local climate and housing conditions. For these purposes, the study was undertaken to investigate the adaptation properties of Aberdeen Angus and Hereford breeds in northern Kazakhstan for the first time.

MATERIALS AND METHODS

The presented research was carried out in 2018 in the farms of North-Kazakhstan Region (Zholdybai Agro farm) and of Akmola Region (AKA LLP, Uryupinskiy and C LLP, Altyndan LLP). Four experimental groups, each consists of 30 second generation Aberdeen Angus and Hereford heifers were kept based on analogue pairs method to study their acclimatization, adaptation, dam characters and productivity. These animals were daughters of imported cows and were 18-19 months old with the live weight of at least 350 kg.

In the course of the study, following characteristics were studied and assessed using appropriate methods. Growth of own generation heifers over their live weight and weight gains (change of weight of all animals) were recorded. The quantity of pasture forage (grass) was considered using the method of reverse calculation. Chemical composition of foodstuff used in the research was defined in the Laboratory of Assessment of Milk and Feed Quality (LAMFQ) of Scientific-Innovation Center of Animal Breeding and Veterinary Medicine LLP and in the laboratory of S. Seifullin Kazakh Agro Technical University. The LAMFQ is equipped with modern infrared analyzers manufactured by FOSS Analytical (Denmark), which is a leader in manufacturing of technological equipment for determining the quality of agricultural products.

Zoo-technical analysis of vegetable feed stuff for experimental animals was carried out using the method of nondestructive infrared analysis on IR-analyzer NIRS DS 2500. Currently, there are global calibrations calculated based on chemical composition of local feed. Body temperature of second-generation heifers was measured using the medical thermometer. The temperature was measured per rectum (in bung gut). Besides characteristics such as respiration rhythm and depth, respiratory minute volume using the masking method, oxygen intake using Douglas-Holden method, and perspiration rate through absorption by calcium chloride, were determined.

To assess the thermal resistance Rauschenbach (1975) used thermal resistance index. This method was developed with account of the revealed dependency relations of body temperature fluctuations on ambient temperature change. Based on this approach, the coefficient of body temperature regression depending on the ambient temperature was calculated. This allowed determining of body thermal resistance in any temperature higher than 30ºC.

The thermal resistance coefficient was calculated using the formula:

$$TRI = 2\ (0{,}6t_2 - 10\Delta T + 26) \quad \ldots(1)$$

Where; t_2 is ambient temperature under temperature

shock; and ΔT is difference in body temperature at day time under high ambient temperature and in the morning in a thermo neutral zone.

Functional activity index was calculated using the methods as described by Kovalchikov (1987). Ethological performance of experimental animals was studied using the methods of Velikzhanin (2004) through visual observation and behaviour time tracking within 24 hours. Following behaviour elements were taken into consideration: duration of lying, standing, consumption of feed and water, movement, etc. In addition, time spent on certain behaviour elements in absolute and relative terms was determined.

Adaptation of experimental animals to environmental conditions was studied through observing the changes in hair covering in winter and summer seasons. Hair mass from a surface unit was defined as well as hair length, thickness and structure using the methods described by Arzumanyan (1954).

Digital material was biometrically processed according to the method of Kryuchkov and Marakulin (2011) with the use of Microsoft Excel 2017.

RESULTS AND DISCUSSION

We carried out investigations on the adaptation of imported Aberdeen-Angus and Hereford cattle to new feed and climate conditions such as housing, and economic characteristics of their off spring in new conditions of North-Kazakhstan (Zholdybai Agro Farm) and Akmola (AKALLP, UryupinskiyandC LLP, Altyndan LLP) oblasts. Average live weight of second-generation Hereford and Aberdeen Angus heifers are shown in Table I.

When studied the change of the live weight of experimental heifers in the period from their birth until 18 months of age, it was established that Hereford heifers carried the average live weight of 28.2 kg at birth, which was 22.5% (23.8 kg) more than their Aberdeen-Angus herd mates. At the end of the growing period Aberdeen Angus heifers had the highest live weight (384.7 kg), which was 18.9 kg more than Hereford heifers. As is depicted in the Table I, all experimental groups of Aberdeen Angus breed surpassed Hereford by live weight to a high degree of accuracy ($p \leq 0{,}001$).

Aberdeen-Angus heifers had the utmost relative growth rate in the period between 15 and 18 month of age, which was 7.6% higher than their Hereford herd mates. Technology of beef cattle housing in the studied farms includes three technological periods: housing of cows with suckler cows, nursing and fattening of young stock. All groups were similarly fed in accordance with the detailed feeding norms and planned live weight gain. Livestock watering was performed through individual automatic waterers with water temperature of more than 10°C.

The diet of heifers consisted of mixed herbs hay, wheatgrass hay, meadow hay, holy clover, haylage, sunflower oil cake, straw, and barley groats. The diet contained 1.9-2.4 energetic feed units, 17-18 MJ of metabolic energy, 85 g digestible protein and 1.9-2.2 kg of dry substance on 100 kg of live weight.

Chemical analysis of feed stuff prepared by Altyndan LLP and AKA LLP was conducted, and content of water, dry substance, crude ash, protein, fiber, fat, calcium and phosphorus in 1 kg of feed in dry substance (%) was determined (Table II).

As it is shown in Table II , mixed herbs hay of Altyndan LLP refers to third class; wheat grass hay of AKA LLP contains insufficient quantity of protein. All hay types in farms were rich in fibre whereas Alfalfa haylage of Altyndan LLP has the elevated content of fiber. According to the content of crude fibre. all types of haylage belonged to the second class. According to protein content, haylage of AKA LLP belonged to the first class, however, based on fibre content it belonged to the second class. Quality of barley corresponds to all characteristics.

Most important parameters for animals to acclimatize to new climate are respiratory rhythm. heart rate and body temperature. These are considered indicators of a relative norm of vital functions. We studied these characteristics in imported heifers of experimental groups in various seasons because the northern region of Kazakhstan is defined by sufficiently high variability of climate conditions throughout the year compared to regions of animal import. There are convincing evidences that testified to ambiguousness of physiological standards in imported animals in new adaptation conditions for two or three generations.

Clinical scores of heifers in various seasons are shown in Table III. With underlying difference between breeds ($p \leq 0.05$-0.001) a certain body temperature change in various seasons was revealed within the range of 37.5-38.9°C in experimental groups. This factor has changed in ales degree in Aberdeen-Angus heifers (fluctuations between 37.6 and 38.7°C). while in their Hereford herd mates, body temperature fluctuations achieved the level of 0.4-0.6°C and varied from 37.5 to 38.9°C. Along with that these fluctuations were within the physiological norm. All experimental animals were characterized by temperature reduction in summer (38.4-38.6°C) and elevated temperature in autumn (38.9-38.7°C). A high ambient temperature is the main destabilizing factor of acclimatization. Namely the high temperature takes a heavy toll on beef and milk productivity as well as homeostasis, genetic productivity and reproductive performance.

Table I. Change of the live weight (kg) of second generation heifers.

Indicators	Age (months)					
	At birth	6	8	12	15	18
Hereford breed, n = 30	28.2±0.3	183.2±2.4	201.7±3.3	282.9±5.7	323.5±2.3	365.8±5.7
Aberdeen Angus breed, n = 30	23.8±0.4	188.3±3.1	207.1±4.5	296.5±6.2	308.2±3.1	384.7±3.6

Table II. Nutritive value of feed stuff.

Feed stuff	Water content %	Crude protein %	Crude fat %	Crude fibre %	Ash %	Calcium %	Phosphorus %
Altyndan LLP							
Mixed herbs hay	5.0	12.27	3.16	28.72	9.62	1.04	0.2
Wheatgrass hay	6.2	8.08	2.85	31.72	8.49	0.77	0.28
Meadow hay	5.6	11.28	2.48	32.08	8.05	0.79	0.24
Haylage (grass sorghum)	58.3	5.21	3.43	15.2	2.48	0.83	0.32
Sunflower oil cake	12.1	16.18	9.91	28.7	7.16	0.30	0.820
Concentrates (oat)	18.0	10.95	3.71	10.19	4.47	-	0.11
AKA LLP							
Holy clover	15.2	14.9	2.6	24.7	6.9	0.42	0.23
Meadow hay	5.8	9.98	2.40	29.98	9.55	0.55	0.10
Haylage (holy clover+grass sorghum)	62.12	19.04	4.28	24.28	10.21	1.38	0.30
Grain screenings	13.5	11.41	3.23	7.84	3.01	-	-
Concentrates(oat+wheat)	18.0	11.3	1.92	8.88	3.08	-	0.08

Table III. Physiological characteristics of heifers in various year seasons.

Factors	Breed	
	Hereford	Aberdeen Angus
Winter		
Body temperature, °C	37.5±0.3	37.6±0.2
Heart rate, bpm	74.2±0.3	73.7±0.3
Respiratory rhythm. times per minute	27.5±0.5	27.3±0.4
Spring		
Body temperature, °C	38.9±0.3	38.7±0.2
Heartr ate, bpm	71.7±0.5	71.6±0.5
Respiratory rhythm, times per minute	24.8±0.4	24.5±0.4
Summer		
Body temperature, °C	38.4±0.2	38.6±0.10
Heart rate, bpm	69.6±0.3	69.4±0.3
Respiratory rhythm, times per minute	26.1±0.3	26.3±0.3
Autumn		
Body temperature, °C	38.9±0.3	38.7±0.1
Heart rate, bpm	64.8±0.4	64.7±0.3
Respiratory rhythm, times per minute	23.1±0.3	22.8±0.3

Next, we studied the thermal resistance of beef breed heifers in the second generation (Table IV). Animals of the II and I groups carried the highest thermal resistance indices of 76.4 and 78.0, respectively. They positively exceeded (p>0,05) their herd mates from other groups in this parameter. At the next stage the adaptation coefficient was determined according to Benezra method. In average, the adaptation coefficient values divided up as follows. According to the adaptation coefficient, animals in the I and II groups significantly (p>0,05) surpassed animals of II and IV groups with the result of 5.35 and 7.8, respectively. There were no statistically significant differences between animals were established. Animals in group II also significantly (p>0,05) exceeded heifers of II and IV groups over this criterion. According to these data, the thermo neutrality zone or the zone of comfortable temperature in Akmola and North-Kazakhstan oblasts was within +19-22+27-31°C. It is evident from data that animals of II and I groups carried the maximum adaptability to the elevated ambient temperature, for which less challenging of body defenses was required. These animal groups have better thermal control system, which allowed them using organism resources more rationally in hotter weather specific for summer months in a climate of northern region of Kazakhstan.

Table IV. Thermal resistance index of Aberdeen Angus and Hereford cattle in conditions of northern region of Kazakhstan.

Group	Body temperature in the morning, °C (at the ambient temperature of 22°C)	Body temperature at day time, °C (at the ambient temperature of 31°C)	Body temperature difference in the morning and at day time, °C	Thermal resistance index
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
III	38.39±0.35	39.36±0.17	0.97±0.39	71.1 ±7.54
IV	38.43±0.25	39.38±0.32	0.95±0.41	70.2±3.14

Table V. Behavioral response of heifers.

Behavioral responses/ Duration minutes	Groups			
	I	II	III	IV
Lying	804±6.83	802±7.14	817±9.82	808±9.51
Standing moving	360±14.63	362±16.12	345±13.29	359±11.40
Feed consumption	11.2±2.34	9.2±1.11	5.1±2.01	4.3±2.08
Water consumption	259±12.75	259±17.22	254±11.43	256±11.55
Functional activity index	0.19	0.19	0.19	0.19

Table VI. Pelage state (n=30) of heifers during winter/summer.

Indices	Groups			
	I	II	III	IV
Hair mass from 1 cm^2 (mg)	87.00±0.51 15.85 ±0.49	86.40±0.44 15.70 ±0.79	81.55±0.43 14.05±0.49	82.95±0.77 12.90±0.49
Hair length (mm)	42.85±1.01 13.15 ±0.99	42.90±1.01 13.20 ±1.09	40.20±0.88 15.25 ±1.01	38.70±0.78 15.85 ±0.93
Hair density (pc per cm^2)	1461.10±19.5 803.20±21.03	1460.10±19.7 801.70±18.2	1396.70±19.6 738.15±18.8	1402.30±19.30 754.60±13.80

Table VII. Structure of pelage (%) of heifers during winter/summer.

Index	Groups			
	I	II	III	IV
Beard hair (%)	19.50±0.51 53.80±0.44	19.70±0.32 53.70±0.39	21.10±0.70 52.10 ±0.47	21.60±0.44 52.60 ±0.24
Intermediate hair	20.70±0.40 25.30±0.33	20.90±0.54 25.50 ±0.63	23.30±0.49 25.10±0.33	24.20±0.48 25.20 ±0.45
Down hair	59.80±0.40 20.90 ±0.45	59.40±0.64 20.80±0.45	52.80±0.32 23.10±0.63	53.10±0.42 24.40 ±0.43

The practice of livestock breeding complexes raises many problems, which are directly related to animal behavior, especially in loose housing. In order to determine behavior of animals in the acclimatization period, we used the method of observation of animals during 24 hours. Animal behavior data were registered every 15 minutes. According to the method the lying, standing period, time spent for consumption of feed and water were registered; the period of moving was registered separately. Collectively, the data is presented in Table V.

Most importantly, we observed that highly adaptable animals spent less time for eating. They consumed feed approximately at 9.10-12 times. Animals of I, II and IV groups were characterized by a less period of lying, i.e. 804, 802 and 808 minutes, respectively. The longest period of lying was registered in Aberdeen-Angus animals of AKA LLP which was 817 minutes. The lying time factor is the evidence of passive behavior of livestock.

The longest period of standing was typical for Hereford animals in Altyndan LLP (363 minutes). Animals of all groups carried the functional activity index of 0.19. According to other indices animals, group I and II (Hereford heifers) shown a relative advantage, as they were more active, spending additional time for moving and eating.

The structure and special characteristics of pelage and skin of large cattle are important for adaptation to low temperature conditions. Reasonable evidences have established differences between breeds, age and seasonal differences in thickness of skin and structure of pelage.

Results of analysis of pelage state of experimental animals are shown in Table VI. According to hair mass from one square centimeter of skin in summer time heifers of experimental group I (15.85 mg) and II (15.70 mg) shown advantage, and significantly ($p>0,05$) exceeded their herd mates compared to group III and IV (14.05 and 15.2 mg/cm^2 respectively). In winter, heifers of I and II groups also carried advantage, and based on this parameter, significantly ($p>0.05$) exceeded from their herd mates compared to other groups.

In summer season, animals of the I (13.15 mm) and II group (13.2 mm) had significantly ($P>0,05$) smaller length of hair than animals of the III and IV groups (15.25 and 15.85 mm respectively). This means that in summer time they had shorter hair, which is a good adaptation sign, as it helps the process of sweat evaporation from the skin surfaces and therefore increases thermoregulation efficiency.In winter animals of group I (42.85 mm) and II (42.9 mm) developed significantly ($p>0.05$) longer hair than those of animals in group III and IV (40.2 and 38.7 mm, respectively). The structure of pelage of experimental animals is shown in Table VII. Specific weight of beard hair in summer time was higher in animals of group I (53.8%) and II (53.7%), which significantly ($p>0.05$) surpassed the herd mates from III and IV groups. As it was discussed previously, the increased content of beard hair in pelage structure is preferential for summer time. At the same time, animals of I and II groups showed the least content of down hair in summer time (20.9 and 20.8%, respectively) which was significantly ($p>0.95$) less than the value of the rest of experimental animals. Thus, heifers in gorup I and II groups depicted the best possible pelage structure, maximum adaptation to the temperature conditions both in winter and in summer.

DISCUSSION

One of the most typical features of all creatures is the inability to adapt to changing environment conditions. As environment conditions are inconsistent, this ability not only provides a possibility of life itself, but also is a reason for evolutionary transformation of organisms. Farms, where the study was carried out, have sufficient quantity of natural forage lands for planned receiving of live weight gain that provides the weight of heifers, by 18 months of age, within the range of 350-380 kg, and successful insemination. It allows sparing of winter feedstuff and well use of pastures.

The main factor providing normal running of vital processes in animal organism is a relative consistency of body temperature. Based on variations (differences) between breeds ($p\leq0.05$-0.001), certain changes in the body temperature during various seasons were recorded. These started from 37.5°C in experimental groups and a lesser extent was observed in Aberdeen Angus heifers (fluctuations from 37.6 to 38.7°C), while body temperature fluctuations of their Aberdeen Angus herd mates achieved 0.4-0.6°C and varied from 37.5 to 38.9°C (in Herefords). Nevertheless, these fluctuations were within the physiological norms.

Many scientists believe that normal body temperature of large cattle of temperate zone is 38.3.39.4°C. With increasing of ambient temperature higher than 10°C, the body temperature of temperate zone large cattle increases as well. Adaptation capabilities of large cattle to new climatic conditions can be assessed on animal behavior. Findings of the present study showed that better adapted animals have spent less time for eating. They consumed feed approximately at 9.10-12 times. Animals of group I, II and IV groups were defined by a less period of lying i.e. 804, 802 and 808 minutes, respectively. Data presented in this study comply with the research of Arnautovskiy and Murashkin (2015), who have studied characteristics of adaptation of Hereford heifers imported from Australia to

conditions of Amur oblast and influence of experimental feed supplements on adaptation stress weakening.

Study of the pelage state of animals in the course of adaptation showed that Hereford heifers carry the best possible pelage structure and maximally adjusted to temperature conditions of Northern Kazakhstan. Based on publically available data, it is possible to state that the pelage and skin of cattle change significantly during the year, which contributes to better adaptation and thermal regulation of animal organism (Pozdnyakova *et al*., 2015).

CONCLUSIONS

The presented data conclude that change of the live weight of Hereford heifers of second generation between the ages of 18 and 22 months shown the average live weight of 378.5 and 375.2 kg, which was respectively 8.7 and 20.6 kg or 2.2-5.4% more than their Aberdeen Angus herd mates. The diet consisting of mixed herb shay, wheatgrass hay, meadow hay, holy clover, haylage, sunflower oil cake, barley straw and barley groats contained 1.9-2.4 energetic feed units, 17-18 MJ of exchange energy, 85 g of digestible protein and 1.9-2.2 kg of dry substance for 100 kg of live weight. Hereford heifers of second generation had a sufficiently high adaptation potential that showed a fast acclimatization to the changed environmental conditions, and adaptation to conditions of housing and feeding. Thus, the high thermal resistance index within the range of 78.1-74.3 was registered in animals.

Based on our observations, the thermoneutrality or comfort temperature zone for Aberdeen-Angus and Hereford breeds in a climate of Akmola and North-Kazakhstan oblasts was in the range of +19-22 to +27-31°C. The better-adapted animals spent less time on consuming feed; they took feed approximately at 9.10-12 times. Animals of group I, II and IV were defined by the lesser period of lying, i.e. 804, 802 and 808 min, respectively. All animals in the study had a same functional activity index (0.19). Based on other parameters, animals of group I and II (Hereford heifers) hold a comparative advantage; they were more active, spending more time for moving and eating. According to hair mass from 1 cm^2 heifers of group I and II groups have significantly ($p>0.05$) surpassed their herd mates from the III and IV groups; in summer time for 11.7-10.6; 18.7-17.9 and 4.1-3.2%, respectively whereas in winter time for 6.3-5.7; 4.7-4.0 and 3.5-2.8%, respectively.

Statement of conflict of interest

The authors declare no conflict of interest.

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