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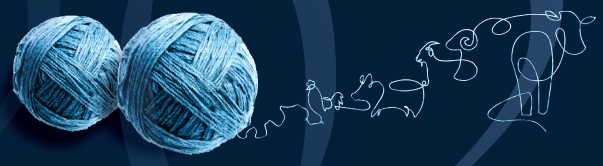
MODERN TRENDS IN LIVESTOCK PRODUCTION

2021



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Belgrade - Zemun, SERBIA

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INFLUENCE OF CATTLE REARING CONDITIONS ON HEALTH, REPRODUCTION, GROWTH, MILK YIELD AND MEAT AND MILK QUALITY

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Abstract: The paper describes the effects of different rearing conditions as possible stressors on health, reproduction, growth, milk yield and quality of meat and milk. It was pointed out that numerous internal and external factors of cattle affect the physiological processes, health, reproduction, growth, milk yield and quality of milk and meat as very strong stressors. They are especially important when acting immediately after parturition, i.e. in the puerperium in cows and immediately after birth in calves. In intensive cattle production, the most important complex stressors regardless of origin, and physiological conditions in which these animals are more susceptible to distress are parturition, calf birth, puerperium, intensive lactation, machine milking, oestrus, high pregnancy, dry period, grouping of animals, disturbed social relations, dehorning, castration, hoof trimming, transport, sudden changes in microclimatic conditions and feed quality, etc. Excessive disturbances before slaughtering cattle also cause a strong stress reaction. In modern housing systems, animal disturbance, immobilization of animals, restriction of movement, significant reduction of living space, strong painful stimuli, dystocia, pain during uterine prolapse, castration and acute inflammatory processes in the udder and uterus are also strong stressors. Unfavourable social relations between animals in the group are usually very strong stressors that lead to disturbances of their behavioural patterns. As a consequence of the action of numerous stressors, behavioural disorders, reduction of growth and milk production, the occurrence of metabolic and reproductive disorders, the occurrence of infectious diseases, reduction of meat and milk quality most often occur.

Key words: cattle, rearing conditions, reproduction, growth, milk yield, meat and milk quality

Introduction

Numerous internal and external factors of cattle affect the physiological processes, health, reproduction, growth, milk yield and quality of meat and milk as stressors. Many scientists have contributed to the clarification and deeper understanding of the mentioned effects *(Hristov and Bešlin, 1991; Broom and Fraser, 2015; Collier et al., 2017; Williams, 2019)*. An integrative approach relating to the biology of stress in farm animals was given by *Wiepkema (1987)*. The basic principles and implications for animal welfare in the biology of animal stress were considered in details *by Moberg and Mench (2000)*. In the meantime, a significant contribution to the consideration of the stress reaction of domestic animals in our country was given in the monograph by *Hristov and Bešlin (1991)*. Earlier, *Dantzer and Mormède (1983)* were discussed the need to reevaluate stress in farm animals. It should always be borne in mind that the occurrence of stress reactions in cattle depends primarily on the type, intensity and degree of stress-triggering factor *(Hristov and Bešlin, 1991; Hristov and Vučinić, 1991)*. According to the literature data in cattle intensive production, the most significant complex stressors are related to rearing and microclimatic conditions, nutrition, machine milking, grouping of animals, transport and many procedures of breeders *(Wiepkema, 1987; Hristov and Bešlin, 1991; Kadzere et al., 2002; Grandin, 2006; Herbut et al., 2018; Herbut et al., 2019; Williams, 2019, Benni et al., 2020)*. Physiological conditions in which these species of animals are susceptible to stress reactions are calving, calf birth, puerperium, intensive lactation, oestrus, high pregnancy, dry period, etc. *(Hristov and Bešlin, 1991; Broom and Fraser, 2015; Williams, 2019)*. In addition, inappropriate handling of animals, painful surgery procedures, restriction of movements, reduction of living space and health disorders, such as dystocia, uterine prolapse and acute inflammatory processes in the udder and uterus are also potential stressors (*Bova et al.*, 2015). The aim of the paper is to consider the most important literature data on influence of cattle rearing conditions on health, reproduction, growth, milk yield and meat and milk quality.

Influence of stressors on health, reproduction, growth, milk yield and quality of meat and milk

Dairy cattle face remarkable metabolic and physiological changes during the transition from late gestation to early lactation in preparation for calving and milk

production. The intense metabolic processes are accompanied by modification of energetic metabolism and by an increase of oxygen consumption. This enhances metabolism severely, resulting in a raised production of reactive oxygen species and leading to the metabolic stress (*Contreras and Sordillo, 2011; Wathes et al., 2013*). This metabolic stress leads to an increased risk of many health conditions, including mastitis, metritis, ketosis, and displaced abomasum *(Wisnieski et al., 2019)*. The most commonly used biomarkers to monitor metabolic stress in cattle are nutrient metabolism biomarkers, including non-esterified fatty acids, beta-hydroxybutyrate and body condition score. These biomarkers represent the balance of mobilization of excess body fat tissue as a result of negative energy balance *(Sordillo and Mavangira, 2014)*.

It has been known for decades that stressors of different nature and intensity participate in the development of bovine acetonaemia *(Shaw, 1956; Radostits et al., 2006)*. A meta-analysis and review of diseases, reproductive performance, and changes in milk production associated with subclinical ketosis in dairy cow were presented in the paper by *Raboisson et al. (2014*). Dairy cows, selected for high production, often show subclinical symptoms of acetonaemia in different housing conditions, most often in the period immediately after calving, i.e. in the puerperium, when milk production gradually increases *(Zhang et al., 2012; Zhang and Ametaj, 2020)*. There are many risk factors for subclinical and clinical ketosis and association with production parameters in dairy cows (*Vanholder et al., 2015; Tatone et al., 2017)*. This disease is common in susceptible dairy cows that are subjected to sudden adverse stimuli from the environment. It has been established that clinically manifested acetonaemia can occur in some cows if their organism is exposed to prolonged stimulation and thus to the load on the adrenal cortex during the period of maximum milk production *(Vanholder et al., 2015; Kushwah et al., 2020)*. From research on changes in the adrenal cortex and anterior pituitary gland in highly productive dairy cows, in which clinical signs of acetonaemia were found in response to known stressors, conducted in 1950, this disease of cows has been used extensively in general studies of pituitary-adrenal function *(Zhang and Ametaj, 2020)*.

Common biological materials for the analysis of cortisol or its metabolites are blood, saliva, urine, faeces and hair *(Zhang et al., 2012; Meyer and Novak, 2012; Heimbürge et al., 2019; Zhang and Ametaj, 2020)*. In these materials, except for the hair, the measured cortisol levels represent only a retrospective timespan of a few minutes up to one or two days. Accuracy in measuring cortisol is especially important for cattle because their steroid concentration is lower compared to other animal species (*Zhang et al., 2012; Zhang and Ametaj, 2020)***.** The hair cortisol concentration is assumed to be a retrospective marker of integrated cortisol secretion and stress over longer periods *(Heimbürge et al., 2019)*.

The change in cortisol concentration in the first month of life of calves was described by *Hristov (1990)* and cortisol concentration in bovine blood serum by *Hristov et al. (1994)*. The concentration of cortisol in the blood plasma is high in calves' immediately after birth and then gradually reduced over the first two weeks. After that, it remains constant until the age of 15. The influence of some stressors on serum cortisol and glucose of calves has been considered by *Hristov et al. (1991).* It was found that the concentration of cortisol in calves increases immediately after dehorning and moving from individual to group boxes. Gut health, stress and immunity in neonatal dairy calves in terms of the host side of host-pathogen interactions were discussed by *Osorio (2020).* It is highlighted that maternal stressors during late pregnancy cannot only influence colostrogenesis but also compromise adequate intestinal development in the foetus, thus, that further limits the new-born's ability to absorb nutrients, bioactive compounds, and immunity (i.e., immunoglobulins, cytokines, and immune cells) from colostrum. In terms of animal production and neuroendocrine stress response, higher cortisol levels have negative effects on growth rate and feed efficiency and increase the fat lean ratio of carcasses. On the contrary, cortisol has positive effects on functional traits and adaptation *(Mormede and Terenina, 2012).*

Numerous studies have documented the response of the adrenal gland to the injection of ACTH in cattle *(Gwazdauskas et al., 1980; Alam et al., 1986*; *González-de-la-Vara et al., 2011)*. Regarding the rate of secretion, the researchers found a tenfold increase in corticosteroid concentrations within 2 minutes after ACTH injection. Some studies indicate that the application of corticosteroids to calves immediately after birth reduces the absorption of essential immunoglobulins by half, and also delays the endogenous production of certain types of immunoglobulins. The application of ACTH causes a greater increase in the concentration of corticosteroids in the blood plasma than the vein puncture in calves itself. These data that the puncture of the vein and the application of ACTH cause an increase in corticosteroids in the blood plasma are in line with the fact that the applied new stimuli cause a stress reaction in the body of calves *(Gwazdauskas et al., 1980; Hulbert and Moisá, 2016)*. The secretion of ACTH and cortisol is pulsatile in most species, with a pulse frequency of about 90 min, follows a diurnal cycle and is influenced by meals, physical activity, and environmental conditions (*Mormede and Terenina, 2012)*. However, accurate measurement of the activity of the adrenocortical axis is challenging *(Mormede et al., 2007)*.

A review of the physiological and productivity effects of heat stress in cattle was considered by *Farooq et al. (2010)* and *Herbut et al. (2019*), environmental parameters to assessing heat stress in dairy cattle by *Herbut et al. (2018)* and physiological and behavioural effects of heat stress in dairy cows by *Becker et al. (2020)*. Also, a review of heat stress on calves and heifers were presented in detail by

Wang et al. (2020). The impact of heat stress on milk and meat production was presented in detail in the paper by *Summer et al. (2019)*. Furthermore, a review of the impact of heat stress on the immune system in dairy cattle was presented by *Bagath et al. (2019).* Earlier, *Kadzere et al. (2002)* was considered a review of the literature on heat stress in lactating dairy cows. Also, the effect of heat stress on milk production in dairy cows was discussed by *Joksimović-Todorović et al. (2011)*. Generally, a biphasic response of the bovine adrenal gland to acute thermal stress has been established. At the beginning of the exposure, a response was established in the form of a noticeable increase in the concentration of steroids in the blood plasma. In the second phase of exposure, steroid levels dropped to below normal. The too hot environment also contributes to the appearance of reduced food intake, and thus reduced growth and milk production (*Knah et al., 2011; Baumgard and Rhoads, 2012)*. These consequences become noticeable only in a few days. The studies further established a decrease in thyroxine secretion during long-term exposure to heat in cattle. Short-term heat has been found to induce increased secretion of adrenal cortex hormones, while prolonged exposure of the body to heat for several days leads to a decrease in glucocorticosteroid secretion. Similar results were observed after the action of the same stressor for growth hormone concentration. Changes in the values of haematological parameters, as well as the number of somatic cells in milk, in response to prolonged heat stress, were determined *(Collier et al., 2017; Polsky and von Keyserlingk, 2017; Herbut et al., 2018; Herbut et al., 2019)*. It has been established that heat stress has a negative impact on the immune system via cell mediated and humoral immune responses *(Becker et al., 2020).*

A review of effect of heat stress on reproductive performances of dairy cattle and buffaloes was presented by *Dash et al. (2016).* A sudden increase in the concentration of corticosteroids in the blood plasma that occurs during oestrus can be a cause for the manifestation of excitement and an increase in the metabolic activity of the organism of heifers and cows. This is possible because the endocrine changes that accompany oestrus also lead to an increase in adrenocortical activity *(Lyimo et al., 2000)*. During the summer season, animals usually suffer from summer sterility due to prevailing hot and humid conditions *(De Rensis and Scaramuzzi, 2003).* In female animal's age at puberty, oestrous signs, ovulation time, ova quality, conception rate, embryonic development, embryo size, embryo weight and hormonal balance are affected by exposure to heat stress *(Sammad et al., 2020*). The most sensitive to heat stress are growing ovarian follicles. Heat stress-induced changes in growing follicles can be expressed later as compromised maturation and developmental capacity of the ovulating oocyte (*Girma and Gebremariam, 2019*). It was concluded that this phenomenon occurs as a consequence of blockage of the secretion of the anterior pituitary gland, which explains the occurrence of abnormal estrus cycles and a high percentage of embryonic losses in cattle at high ambient

temperatures (*Diskin and Morris, 2008)*. Exposure of cows to strong heat stress leads to an increase in the rate of embryonic mortality, especially in the period immediately after mating (*Hansen, 2007; Lockwood et al., 2017)*. In males, sex hormone levels, spermatogenesis, temporary sterility, libido, ejaculate volume, macroscopic as well as microscopic semen characteristics in an ejaculate are affected, and sperm abnormalities and dead sperm increase by exposure to heat stress *(Fernandez – Novo et al., 2020; Para et al., 2020).*

Bhatt et al. (2021) a detailed review of transportation stress in livestock and its management techniques were presented. The effect of long distance transportation stress on cattle was presented in a review paper by *Damtew et al. (2018).* A review of the welfare of young calves transported by road was given by *Roadknight et al.(2021). Zavy et al. (1992)* effect of initial restraint, weaning, and transport stress on the baseline and ACTH-stimulated cortisol responses in beef calves of different genotypes were described. The mortality rate of young calves may be particularly high after exposure to long-term transport. If the transport conditions are very unfavourable, the reaction of the adrenal gland to the present stressors occurs during the transport itself. Under these conditions, there is an almost instantaneous change in the concentration of corticosteroids, which is a reliable indicator of the stress state of the organism. In addition, it was found that the effect of transport on the concentration of mentioned corticosteroid in the blood plasma, and thus the stress caused, persists, and only after a period of 3 to 4 weeks the level of corticosteroids in the blood plasma returns to previous values. Also, it has been established that the transport of calves for 1 to 4 hours is a stronger stressor (marked by an increase in the concentration of corticosteroids in the blood plasma) than castration, dehorning and 48-hour disabling of water intake. Because transport is a strong stressor that can cause the extensive release of corticosteroids in the blood plasma, the ability of young animals to respond successfully to other strong stressors in the environment, usually bacterial and viral infections, is limited (*Damtew et al., 2018; Kukharenko and Fedorova, 2018*).

Pain at the slaughterhouse in ruminants with a focus on the neurobiology of sensitisation was described by *Mota-Rojas et al. (2021*) and pain evaluation in dairy cattle by *Gleerup et al. (2015).* In these reviews a neurobiological approach is taken to discuss the hypothesis in the light of basic science and extrapolations from existing literature on the slaughter of ruminants. A review of effects of age and method of castration on performance and stress response of beef male cattle was presented by *Bretschneider (2005).* Data of average daily gain and peak plasma cortisol concentration of calves castrated by surgical and rubber banding methods at different ages were analysed.

Effects of stocking and transport conditions on physicochemical properties of meat and acute-phase proteins in cattle were described by *Abubakar et al. (2021*). The

results revealed that the colour, pH, shear force values, water holding capacity, glycogen level, and malondilaldehyde assay concentrations in meat and acute-phase proteins were affected by both distances and stocking densities. Certain transport, including the loading density, environmental conditions, transport duration, and human factors, have caused an increased stress response, as indicated by plasma cortisol, adrenaline, glucose, or LDH levels, which have been associated with deteriorated meat quality (*Xing et al., 2019*). Excessive disturbance of cattle before slaughter leads to an increase in pH and progressive changes in meat colour in the sense previously emphasized *(Grandin, 2006)*. Studies of the frequency of meat discolouration have shown that it occurs in 30% of young bulls and only 8% of ox meat. Studies of emotional disorders in young bulls have shown that the appearance of a change in the colour of the meat can be eliminated if the bulls designated for slaughter are placed in a group not less than 48 hours before being sent to the slaughterhouse. Insemination of females in the period immediately after transport significantly reduces the rate of conception. Exposure to the new environment also causes an increase in the concentration of adrenocortical metabolites in the urine, which can be established up to 3 months. Practical experiences on long-distance transport of animals emphasize the need to do everything to help animals during the first and second day after transport because the most pronounced changes in their behaviour occur during that period *(Grandin, 2006; Weglarz, 2010; Damtew et al., 2018; Roadknight et al. 2021)*.

Further research has shown that even non-painful stimuli can cause an increase in the concentration of corticosteroids in the blood plasma of cows. For example, human contact has effects of acute stress on cows at milking. Leaving the milking machine on the udder, 15 minutes after the cessation of milk secretion, increases the concentration of corticosteroids in the blood plasma above the concentration observed in a normal machine milking. The increase in the concentration of corticosteroids in the blood plasma of cows seems to be maintained as long as the artificial milking stimulus lasts *(Rushen et al., 2001; Hopster et al., 2002)*.

A personal perspective of pain and stress in cattle was given by *Bomzon (2011)* and pain evaluation in dairy cattle by *Gleerup et al. (2015*). Strong painful stimuli in cattle such as the use of an electric prodder, then dystocia, pain during uterine prolapse, surgery and acute inflammatory processes in the udder and uterus lead to a significant increase in the concentration of corticosteroids in the blood plasma. These results support the theory that the activity of the adrenal cortex is a reliable indicator of stress intensity from both the external and internal environment *(Hristov and Bešlin, 1991, Grandin, 2006; Mormède and Terenina, 2012; Herbut et al., 2018)*.

The stress and welfare of farm animals was considered by *Hristov et al. (2007)*. The most important dilemmas regarding the welfare of farm animals were

described by *Hristov et al. (2019).* General principles and good animal welfare practices on dairy cattle farms were considered by *Hristov et al. (2019)*. Many factors contribute to the welfare of calves on the commercial dairy including housing and environment, rearing conditions and birth season, nutritional and health programs, handling and caretaker interactions, herd dynamics, and the common management practices of transportation, euthanasia, dehorning, and teat removal *(Stull and Reynolds, 2008; Samolovac et al., 2019)*. The environment with its physical and social factors in the stages of the early development of the body of calves affects the ability of its body to react to stressors in later life. When calves are kept in pens, they show the significantly less general activity of the organism in comparison with freely kept calves, which are also enabled to suck the mother. If calves are kept in isolation for the first 12 weeks of life, after that period there is a decrease in their grouping activity compared to calves that were not kept in isolation *(Broom and Fraser, 2015; Jensen, 2018; Meagher et al., 2019).*

When calves are exposed to uncomfortable housing conditions significantly reduce their length and noticeably change their sleeping characteristics. Changes in other behavioural patterns of calves also occur in uncomfortable housing conditions *(Broom and Fraser, 2015)*. Modern breeding systems are often associated with the emergence of the establishment of artificial social relations between individuals that are periodically disrupted by events such as the entry of a new dominant individual into the group. Unfavourable social relations between animals in the group are usually very strong stressors that lead to disorders of behavioural patterns. Effects of group housing of dairy calves on behaviour, cognition, performance, and health was analysed by *Costa et al. (2016*). Therefore, for example, ruminant lesions occur in calves as a result of licking the skin of other calves or there is a weaker growth of subordinates compared to the dominant calves in the group when kept on artificial teats *(Hulbert and Moisá, 2016).*

Acute effects of cow-calf separation on heart rate, plasma cortisol and behaviour in multiparous dairy cows were analysed by *Hopster et al. (1995)*. Adult cattle establish stable social relations in the group in free intensive systems with adequate space and manifest minimal conflict situations. Disorders in the social status of cattle when introducing a new individual to the group can cause a decrease in the average milk production of the herd by 5%. Insufficiently adapted cows in large herds often do not maintain lactation for an average of 305 days and have a prolonged calving index *(Broom and Fraser, 2015).* Current knowledge and future directions of social stress as a cause of diseases in farm animals were described by *Proudfoot and Habing (2015*).

It is difficult to assess the significance of very pronounced changes in heart rate and blood pressure in calves during suckling, although in suckling pronounced behavioural and physiological effects stem from the rapid learning process contained in the formation of the natural mother-foetus bond in cattle resulting from an increase in

sympathetic efferent activity *(Meagher et al., 2019)*. In cows kept together with calves, corticosteroid levels in the blood plasma increase before suckling *(Murray et al., 2016*). This increase occurs even if the licking is performed to a lesser extent by the mother, with the levels of increase being lower concerning the group of cows where machine milking and giving milk to calves was applied. These studies show that a period of up to 48 hours after birth is critical for establishing a bond between a cow and a calf. When staying with calves for 24 hours, the sleeping time of the cows after weaning the calves does not change. However, if they spend 48 hours in the presence of calves, the time of sleep and rumination is reduced after weaning the calves. When the calves were separated from the cows after 26 days and placed in boxes near them for a week so that the cows could see and hear them, the time of sleeping and rumination was reduced during the first two days. After two days, the cows re-established normal sleep and rumination behaviour *(Hopster et al., 1995; Enríquez et al., 2011; Veissier et al., 2013; Broom and Fraser, 2015).*

It has been studied how modern breeding methods can induce a stress reaction and the appearance of pathological conditions in dairy cows *(Proudfoot and Habing, 2015)*. The occurrence of foetal membrane retention has been shown to be almost twice as high in dairy cows as in fattening cows in which calves suckle the mother. It was concluded that the differences in this phenomenon occur due to "premature rupture of the placental connection", i.e. due to the separation of the mother from the calves immediately after birth. It occurs similarly in pregnant dairy cows that are kept free in pens where other animals in the group can disturb them. The removal of calves immediately after birth is another acute disturbance of the cow that can inhibit the necessary uterine contractions for the normal ejection of foetal membranes *(Broom and Fraser, 2015; Peter, 2021).*

Conclusion

Based on a detailed review of the literature data regarding the impact of cattle rearing conditions as a stressor on reproduction, growth, milk yield and quality of meat and milk, the following can be concluded:

- A large number of complex stressors can affect the occurrence of different phases of the stress response of the organism of certain categories of cattle in intensive cattle production;
- The occurrence of a stress reaction depends primarily on the type, intensity and degree of novelty of stress stimuli;
- The most significant complex stressors are related to microclimatic conditions, nutrition, machine milking, social relations, moving and regrouping of animals, transport, zootechnical procedures (dehorning, hoof trimming, marking and fixing)

and veterinary procedures (injection and oral treatment, castration and other surgical procedures);
- Physiological conditions in which these species of animals are susceptible to stress reactions are: parturition, calf birth, puerperium, intensive lactation, oestrus, high pregnancy, dry period, etc.

Uticaj uslova gajenja goveda na zdravlje, reprodukciju, prirast, mlečnost i kvalitet mesa i mleka

Slavča Hristov, Branislav Stanković, Dušica Ostojić Andrić, Ljiljana Samolovac, Nevena Maksimović, Marko Cincović, Dimitar Nakov

Rezime

U radu su opisani uticaji različitih uslova gajenja kao mogućih stresora na zdravlje, reprodukciju, prirast, mlečnost i kvalitet mesa i mleka goveda. Istaknuto je da brojni faktori iz životne sredine goveda utiču na fiziološke procese, zdravlje, reprodukciju, prirast, mlečnost i kvalitet mesa i mleka kao vrlo snažni stresori. Oni su od naročito velikog značaja kada deluju neposredno posle porođaja odnosno u puerperijumu kod krava i neposredno posle rođenja kod teladi. U intenzivnoj govedarskoj proizvodnji najznačajniji kompleksni stresori nezavisno od porekla, a i fiziološka stanja u kojima su ove životinje podložnije pojavi distresa su: porođaj, rođenje, puerperijum, intenzivna laktacija, mašinska muža, estrus, visoki graviditet, zasušenje, premeštanje i grupisanje životinja, socijalni odnosi, obezrožavanje, kastracija i drugi hirurški zahvati, obrezivanje papaka, obeležavanje i fiksiranje, injekciono i peroralno tretiranje, transport, nagle promene mikroklimatskih uslova i hrane, stresori antropogene prirode i dr. Suvišna uznemiravanja ili naprezanja pre klanja goveda takođe izazivaju snažnu stresnu reakciju. U modernim sistemima držanja i smeštaja od značaja su i uznemiravanje životinja, imobilizacija životinja, ograničenje kretanja, znatno smanjenje životnog prostora u boksovima, snažni bolni nadražaji, kao primena električnog goniča, zatim distokija, bolovi pri prolapsusu uterusa, hirurški zahvati i akutni inflamatorni procesi u vimena i uterusu kao snažni stresori. Nepovoljni socijalni odnosi između životinja u grupi su obično veoma snažni stresori koji dovode do poremećaja bihejvioralnih obrazaca. Kao posledica delovanja brojnih stresora najčešće dolazi do poremećaja u ponašanju, smanjenja prirasta i proizvodnje mleka, pojave metaboličkih i reproduktivnih premećaja, pojave zaraznih bolesti i smanjenja kvaliteta mesa i mleka.

Ključne reči: goveda, uslovi gajenja, reprodukcija, porast, prinos mleka, kvalitet mesa i mleka

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