

PROBLEMS OF EARLY CULLING OF COWS IN BREEDING STOCKS FOR MILK PRODUCTION

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Abstract: A common problem of dairy cattle in all production systems and production directions is their reduced production life and therefore their reduced lifetime span. Among the main reasons of dairy cattle premature culling the problems related to reproduction, udder and legs are prevailing. The order of these reasons according to their significance is not the same in all dairy cattle populations and depends on production direction, level of production and specific technology of cattle breeding. There are also other reasons of culling but these three groups are the main ones. Due to frequency of their incidence, as well as economic damage which they can cause in dairy cattle production, today they must be taken into account when defining breeding goals for certain breeds and populations of cattle.

Key words: functional traits, leg problems, reproductive problems, udder problems

Reproductive problems as a factor of early culling of cows

Reproductive problems (sterility) are a consequence of action of many exogenous and endogenous factors. The causes of sterility can be different and can be classified in different ways but the most often are: nutritive factors (errors in nutrition- insufficient and deficient nutrition over a longer period), the way of keeping (cow barn and tie stall), infections and diseases of sex organs, decreased function and insufficiency of ovaries and other reproductive organs (functional disorder of reproductive organs, neurohormonal disorders), congenital deficiencies and defects of reproductive organs, insemination errors, diseases of metabolism and interior organs diseases, hereditary factors (existence of lethal and semi-lethal genes), immunological sterility and other factors.

Among all factors that affect reproduction the effect of nutrition (in quantitative and qualitative sense) is the highest (60-75% of overall sterility), while all the other

factors together account for 25- 40% of sterility. This kind of sterility is called "hunger sterility".

An improved nutrition has an effect on the occurrence of oestrous in breeding females of all species of domestic animals. It is confirmed by the results of numerous authors obtained in previous research studies (*Morris et al., 1993*; as well as *McClure, 1961*; *Staples et al., 1990*; *Beam and Butler, 1998*; cited by *Vuković et al., 2011*). Fertility disorders can be a consequence of inadequate nutrition (particularly energy-deficient diet). There is an effect of negative energy balance and high milk yield postpartum on cow fertility status and the occurrence of ovarian cysts. Diet-originated glucose is necessary both for milk synthesis and for normal functioning of central nervous system (CNS), including hypothalamus and hypophysis where GnRH is being synthetized, i.e. FSH and LH. The requirements for milk synthesis, especially at the start of lactation, have a priority over other requirements, what induces silent reproductive functions as a consequence (*Lotthammer 1985*), cited by *Vuković et al. (2011)*.

Properly balanced bovine diets in certain production stages are very important prerequisites for attaining optimal fertility in cows at an annual level. However, nutrition of cows is not the only factor and therefore it is not a warrant for optimal fertility in cows. The occurrence of oestrous in cows, after uterine involution, depends to a great degree on cow body condition. Apart from nutrition, milk yield in the first few months postpartum affects to a great degree the state of cow condition, as well as the expressiveness and duration of negative energy balance.

Apart from "hunger sterility" there is also a "genital sterility" caused by pathomorphological changes in bovine reproductive organs. These changes can be congenital developmental anomalies, but also different acquired diseases of genital organs, most often induced by an infection. Genital sterility might account for 10-15% in overall sterility.

In dairy cattle breeding stocks the fertilization failure, early embryonic loss and resorption of embryo, prolonged or reduced oestrous cycle, delayed ovulation, acyclicity and other problems may often occur as a consequence of action of many exogenous and endogenous factors. Taking into account that these incidents are related to herds and occur occasionally they are also called "herd sterility".

Taking into consideration numerous factors that can affect fertility in cows, as well as the fact that it is impossible to fulfil all requirements that animals have in certain production stages, a decreased fertility in cows (fertility of breeding stock) may occur as a consequence at an annual level. With a view of increasing fertility in cows, particularly in dairy cattle herd, conducting of induction and synchronisation of oestrus is imposed as obligatory. For that purpose preparations of prostaglandine and their analogues are used in several different protocols (administration occurring once, administration occurring twice, repeated administration). The preparations based on GnRH and progestin in combination

with prostaglandines are used for synchronisation of preovulatory follicular development and induction of ovulation.

Vakanjac and Maletić (2013) state that the effect of prostaglandin depends on the stage of a cycle in which it is applied i.e. on the stage of development of corpus luteum. In heifers corpus luteum reacts to prostaglandin administration from the day 5 of the oestrous cycle (from the day 7 of oestrous cycle in cows) all up to day 17 when spontaneous luteolysis by endogenous prostaglandines originating from endometrium occurs. Due to these reasons it is not justifiable to apply hormone in the period up to day 5 and after day 17 of the cycle. The incidence of oestrous upon application of prostaglandine or its analogues depends on the stage of development of dominant follicle in the moment of hormone application. If the preparation is applied in the time of development of dominant follicle of the first follicular wave, the occurrence of ovulation can be expected in 2-3 days. If the preparation is applied in later stage when follicle has lost its dominancy the ovulation can be expected only after 4-5 days when dominant follicle which is going to ovulate is being separated from the second follicular wave. *De Jarnette et al. (2001)*, *Dogan et al. (2008)*, as well as *Perišić et al. (2016)* report the results of hormonal treatments on the incidence of oestrous, i.e. the application of various protocols of induction and synchronisation of oestrous in cows.

Udder problems as a reason of early culling of cows

Among the all udder problems the most common are different types of mastitis. In the occurrence of mastitis 3 bio-systems take place: a cow with its defensive mechanisms, environment with numerous possibilities of transmitting infection and causative agent of mastitis with its infection. All causative agents of mastitis can be divided in two groups: genetic factors (effect of breed or population within breeds) and non-genetic factors (way of cattle keeping, type of bed, type of diet and kind of nutrition, season, way of milking, milking machine, milking hygiene).

The effect of genetic factor on the incidence of mastitis is associated with procedure of improvement conducted in dairy cattle with the view of improving production traits in cows.

Over a few last decades the selection aimed at increasing the milk production was conducted what negatively reflected on the animal's resistance to diseases (mastitis). In that way a production life and lifetime of cows considerably decreased while replacement and repairing rates increased. High replacement and repairing rates significantly negatively affect and increase the cost of milk production. Production traits have a negative genetic correlation with functional traits such as health (general resistance, resistance to mastitis) and fertility in cows. For these reasons in breeding goals and programmes of improving cattle breeds in

some European countries besides improving of production traits the improvement of functional traits is obligatory as well. Economic parameters of milk production depend to a great degree on functional traits. The milking traits, which also include resistance to mastitis, belong to the group of functional traits and they increase profitability of production via decreasing the costs of production (Groen *et al.*, 1997, Rensing, 2005, cited by Bobić, 2014).

In the group of milking traits there are several traits: uniformity of udder quarters (balanced udders), attachment, depth and height of udders, morphological appearance of the parts of udders, shape and dimensions of teats, shape and strength of sphincter, milk flow, udder index, and other. The shape and structure of udders determine predisposition of cow to mastitis. Besides the speed of milk flow the duration of individual stages of milking is very important as well. Thus Bobić (2014), citing Mijić *et al.* (2003), points out that selection of cows with shorter declining stage and longer plateau stage could make an effect on decrease of number of somatic cells in milk i.e. health state of udders could be affected. In cows with too fast flow of milk the risk of incidence of mastitis is increased along with the increase of the number of somatic cells.

At defining breeding goals for high yielding populations of Simmental breed of the direction milk – meat the functional traits are being emphasized. Therefore in Austria dual production has been defined as a breeding goal in a following ratio: 38% milk, 16% meat and 46% functional traits. It is similar in German Simmental in which functional traits account for over 40%. A particular significance is being put on fitness traits of fertility, course of calving, calves resistance and somatic cells. A special emphasis is on increasing the length of lifetime and production life as well as on realising an overall lifetime production of milk of minimum 30000 kg with realising lactation minimums which are defined in breeding goals (www.asr-rind.de) cited by Perišić *et al.* (2014).

Nemeš (2016) citing Rosenberger *et al.* (2004) reports that raisers of Bavarian Simmental cattle recorded the decrease in longevity, higher percentage of still born and dead calves, more frequent incidence of hereditary disorders, direct relationship between produced yield of milk protein and health as main deficiencies of selection on higher production of milk.

The opinion of cattle raisers and researchers about cross-breeding of dairy cattle (Fleischer *et al.*, 2001; Weigel and Barlass, 2003; cited by Nemeš, 2016) indicate that the research and practical experiences showed that unilateral selection which in the last decade was conducted exclusively towards high production of Holstein-Friesian breed, irretrievably affected metabolism, fertility and health of animals in the most unfavourable way while in cross-bred animals (mostly crosses of Holstein cows with Brown Swiss and Jersey bulls), improved health, fertility, longevity and profitability of production was observed. Many authors think that cross-breeding is a key for increasing the level of fertility and prolonging the life span of dairy cows. Antagonism between constant increase of milk production and

decrease (fall) of fertility is a growing problem in German Holstein as well, as reported by *Freyer et al. (2008)*, and cited by *Nemeš (2016)*. The same authors think that cross-breeding of dairy cattle can be an efficient way for improving functional traits and health of cows for milk production.

In the countries which have a great populations of dairy cattle it is possible to conduct cross-breeding of the parts of those populations. The results of conducted research on farms of dairy cattle in California are reported by *Heins et al. (2012a)* and *Heins et al. (2012b)*. By the analysis of data it was determined that all groups of crossbreds had significantly better traits of fertility and health compared to cows of Holstein during the first five lactations.

Table 1. The results of cross-breeding of Holstein with other breeds (*Heins et al., 2012a*)

Traits	Holstein	Holstein x Nordic breed	Holstein x Montbeliard	Holstein x Scandinavian red
Days to 1 st conception	70	66	63	66
Service period	148	128	122	136
Number of somatic cells (1000)	121	119	98	108
Milk yield (kg)	11417	9843	10774	10627
Yield of protein and milk fat (kg)	762	687	738	733
Survival until 2 nd calving (%)	75	88	89	85
Survival until 3 rd calving (%)	51	73	75	71
Survival until 4 th calving (%)	29	53	55	50
Duration of production life (day)	946	1263	1358	1306
Lifetime profit (\$)	4347	5467	6503	6272
Daily profit (\$)	4,17	3,89	4,39	4,32

Crossbred cows also had significantly longer lifetime span what had an effect on production profitability (*Heins et al., 2012b*). The effects of selection aimed at improving fertility traits cannot be attained in a short period of time. In addition, the situations in which it is not possible to conduct cross-breeding are frequent (small population of cattle of some breed). In such cases besides improving non-genetic factors which affect fertility (nutrition, way of keeping), there remains as an additional possibility, the application of hormones in the regulation of reproduction (*Perišić et al., 2016; Vakanjac and Maletić, 2013*). Information about the need of introducing functional traits in defining breeding goals for certain breeds can be found in the research papers by *Perišić et al. (2008); Perišić et al. (2009); Perišić et al. (2012)*.

Leg problems (lameness) as a factor of early culling of cows

Lameness is, besides mastitis and sterility, one of the most important economic and health problems in modern farm management of dairy cows and very

often a predisposing factor for the occurrence of the other two. *Relić et al. (2015)* concluded that in 88% lame cows some of the indicators of disturbed fertility (prolonged service period, higher index of insemination and/or prolonged interval from the first insemination postpartum up to a successful conception) are observed.

Lameness represents inability to use the limbs functionally along with the changes in gait which occur because of the pain and bad feeling in that part of the body (*Clarkson et al., 1996*). It occurs in all intensive production systems of dairy cows while a frequency of incidence and consequences thereof differ from farm to farm depending on the conditions of breeding. There are numerous causes of the occurrence of lameness, the claw disease being the most frequent one in cattle (*Toholj and Stevančević, 2015; Hristov et al., 2016*). Among the most common and the most important claw diseases are digital and interdigital dermatitis, interdigital phlegmon and laminitis, among which the first three are of infectious character and of similar aetiology (*Weber et al., 2013; Relić et al., 2015; Bojkovski et al., 2020*).

Claw disorders are usually present in more than half of the animals in a herd (in some herds in more than 70% cows) and lameness occurs in about 30% animals at an annual level (*Griffiths et al., 2018*). The economic losses due to lameness take place because of a consequent decrease of milk production, poor condition of the animal (decreased food intake and prolonged resting), problems in reproduction (less visible signs of oestrous and/or absent oestrous), increased working hours and treatment costs for affected cows, as well as a premature culling from breeding stock and from production in general. A direct reason of premature culling happens in the case when claw disorder has developed into incurable, chronic course and when the animal health is permanently impaired and it is no longer capable for production. An indirect reason is seen in the case when due to claw and leg disorders there occurred some other disease what led to a decision that the animal be removed from production and sent to economic slaughter.

A decrease in milk production due to claw disease may be even up to 30% (*Toholj and Stevančević, 2015*). The overgrown dermis of toes, even without visible lameness, can affect the decrease of milk production from 0.5 to 1 liter of milk daily per cow. In breeding stocks in which claw disease occurs in 5 to 10 per cent of animals the decrease of daily quantity of milk can be up to 4 to 5 liters of milk per cow (*Relić and Radenković-Damnjanović, 2009; Stojić et al., 2012*). The occurrence of lameness shows that animal feels a strong pain what is an indicator of its impaired welfare. If a considerable number of animals in the herd has an expressed lameness it can be a sign that general standards of welfare are not fulfilled in the herd (*Whay et al., 2003*).

Risk factors for incidence of lameness in cows

Factors which represent the risk for the occurrence of claw disease can be classified into two groups. The first group includes the factors whose effect it is not

possible to avoid: the age of an animal, season, pregnancy and stage of lactation, parity, previous diseases and genetic predisposition to claw disorder. The number of interventions due to pathological changes on claws usually increases with increased age of animal and increase of the number of lactations in order while the season and parity are in a positive correlation with the incidence of some of claw diseases (Mülling *et al.*, 2006; Weber *et al.*, 2013; Relić *et al.*, 2015).

The second group of factors on which it is possible to make an effect includes the conditions of housing, hygiene of cows, application of biosafety measures, social relationship in the herd, diet composition and skill at performing the corrections of claws. An increased risk for incidence of claw infectious diseases is observed in animals that have no chance of using pastures and whose movements are restrained, as well as in the farm facilities in which the cattle population is large (Somers *et al.*, 2005; Barker *et al.*, 2009).

According to Mülling *et al.* (2006) the state of claws in cows and occurrence of lameness are mostly affected by quality, hygiene and comfort of the surfaces for lying and walking. These surfaces must not be slippery (for example, wet, smooth concrete covered by liquid manure and faeces, wet and dirty straw) or damaged in any way and covered by small stones which can stuck in the claw sole. Twisting and swinging of lower part of limbs on hard and abrasive floor (for example, at sudden changes in body positions) can lead to damage of live parts within the capsule of dermis. In addition, anatomic structure of the bones of hind limbs in cattle (initial asymmetry of metatarsal bones) can cause that on a hard floor outer claw (external toe) bears greater burden. The consequence thereof is a more intensive growth of dermis on outer toe than on the internal one what affects further increase of pressure. Negative consequences of a hard floor can be avoided by an expert and regular shortening of claw dermis.

Composition of a ration for cows is also very important for the incidence of claw disease and lameness. Rumen microbiota needs six weeks to adapt to sudden change in the composition of a diet and during that time present microelements and other nutritive materials will not be absorbed at an optimal level. Zinc, biotin, iodine, selenium, copper, manganese and cobalt are particularly important in prevention of claw disease.

The share of certain components in a diet (more than 50% of dry matter) can affect biochemical processes in rumen and induce impossibility of synthesis of sufficient quantity of biotin which by its activity affects preventing rumen acidosis due to accumulated lactates. A lactic acid, high yield of carbohydrates and small quantity of fibres in diet, energy rich diets and nutrition by maize silage are reported as significant for the incidence of acidosis and therefore for the incidence of lameness as well (Mülling *et al.*, 2006).

Diet which induces rumen acidosis very often has laminitis for a consequence. The reason why these two states may be associated is a fall of rumen pH what results in a death of a certain number of microorganisms and in releasing

of the content from their cells. It is thought that the greatest role in the incidence of laminitis have vasoactive matters (histamine) released from decomposed bacterial cells which enter the bloodstream and lead to damage of corium of claw but also a great importance is given to bacterial endotoxins, lactic acid and other biologically active substances (*Radojičić et al., 2009*).

An excessive quantity of protein in a diet means that by its degradation there occurs a greater quantity of aminoacids and ammonia as well (*Grubić and Adamović, 2003*), i.e. creation of some toxic products which can act as allergens. The greatest risk for incidence of claw infectious diseases is purchase of new animals. For that reason, before their including into the herd and immediately after their arrival, it is necessary to have records about a health status of every animal and herd which the animals come from and which should prove that an animal be free from digital dermatitis and other infectious claw diseases. Newly purchased animals should be isolated from other animals at least 2-3 weeks during which period the housing must suit the needs of dairy cows regarding comfort, hygiene and quality of air, with minimal action of stressors. Suspicious cows should be isolated and treated immediately upon their arrival while for all animals it is recommended thorough claw cleaning and trimming followed by preventive foot bathing over a few consecutive days upon arrival on the farm.

Preventing the contact with other ungulates, hygiene of litter and bed, barn paths, yards, disinfection of equipment for claw trimming, then cleansing, trimming and disinfection of foot, as well as the isolation of affected animals and their timely and adequate treatment represent biosafety measures in control of claw disease. Their aim is to prevent the occurrence of a disease causative agent on the farm and its spreading inside it (*Mülling et al., 2006; Relić and Radenković-Damnjanović, 2009*). Non-regular and selective conducting of these measures represents the risk not only for the incidence of claw disease in the herd but also of its spreading inside it.

Conclusion

A decreased production life in dairy cattle is a common phenomenon in breeding stocks of dairy and combined production traits (direction milk-meat) nowadays. Main reasons of premature culling of cows are: reproductive problems, problems of udders and claw and leg disorders.

Functional traits (regular fertility, general resistance and resistance to mastitis, good fundament - legs, claws), are regularly included into breeding goals and programmes of high yielding cattle breeds. The ways of improving aforementioned traits are: selection in pure breed but also an application of ameliorative cross breeding. Improvement of functional traits by application of these methods of improvement is a slow process if the effects are regarded per generations. Particularly the effects of selection aimed at improving fertility traits

cannot be regarded in a short period. With of view of faster improvement of fertility some countries with large populations of dairy cattle resort to the application of classical two-breed crossbreeding or to the application of rotational crossbreeding. Along with the changes in hereditary basis a negative effect of all non-genetic factors should be eliminated, i.e. to fulfil all requirements (nutrition, way of keeping, milking hygiene and prevention of mastitis, regular trimming of claws, etc.) that animals have according to certain production stages.

The goal of these activities is to increase the longevity in dairy cattle what directly affects the decrease of replacement and repairing rates in breeding stock and the increase of the economy of production.

Problemi ranog izlučenja krava u zapaćima za proizvodnju mleka

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Rezime

U svim proizvodnim sistemima i proizvodnim usmerenjima skraćen je proizvodni vek krava. Posebno je to izraženo kod specijalizovanih mlečnih rasa, kao i rasa kombinovanog smera mleko:meso. Glavni razlozi prevremenih izlučenja krava iz proizvodnje su problemi u vezi sa reprodukcijom, vimenom i nogama. Redosled ovih razloga po značaju nije isti u svim populacijama krava, već zavisi od proizvodne usmerenosti, nivoa proizvodnje i konkretne tehnologije gajenja krava. Postoje i drugi razlozi izlučenja krava, ali ove tri grupe su glavne. Zbog učestalosti njihove pojave, kao i ekonomskih šteta koje uzrokuju u govedarskoj proizvodnji, funkcionalne osobine (redovna plodnost, opšta otpornost i otpornost ka mastitisu, dobar fundament - noge, papci), redovno su uključene u odgajivačke ciljeve i programe visoko proizvodnih rasa goveda. Naćini poboljšanja navedenih osobina su: selekcijom u čistoj rasi, ali i primenom meliorativnog ukršćanja. Poboljšanje funkcionalnih osobina primenom ovih metoda oplemenjivanja je spor proces, ako se efekti sagledavaju po generacijama. Posebno se efekti selekcije u cilju poboljšanja osobina plodnosti, ne mogu sagledati u kratkom roku. U cilju bržeg poboljšanja plodnosti, pojedine zemlje koje imaju velike populacije mlečnih rasa goveda, pribegavaju primeni klasićnog dvorasnog ukršćanja ili primeni rotacijskog ukršćanja. Uporedo sa izmenom nasledne osnove, treba eliminisati negativni uticaj svih negenetskih činilaca, odnosno ispoštovati sve zahteve (ishrana, naćin držanja, higijena muže i prevencija mastitisa, redovna korekcija papaka i dr.), koje životinje imaju u skladu sa proizvodnim fazama. Cilj svih aktivnosti je povećanje

dugovečnosti krava, čime se direktno utiče na smanjenje remontne stope u zapatu i povećanje ekonomičnosti proizvodnje.

Ključne reči: funkcionalne osobine, problemi reprodukcije, problemi vimena, problemi nogu

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References

- BARKER Z.E., AMORY J.R., WRIGHT J.L., MASON S.A., BLOWEY R.W., GREEN L.E. (2009): Risk factors for increased rates of sole ulcers, white line disease, and digital dermatitis in dairy cattle from twenty-seven farms in England and Wales. *Journal of Dairy Science*, 92, 1971–1978.
- BOBIĆ T. (2014): Povezanost morfoloških, muznih i zdravstvenih značajki vimena krava. Doktorska disertacija. Poljoprivredni fakultet, Sveučilište Josipa Juraja Strossmajera, Osijek.
- BOJKOVSKI J., HADŽIĆ I., PRODANOVIĆ R., VUJANAC I., NEDIĆ S., ARSIĆ S., BECKEI ZS., DOBROSAVLJEVIĆ I., PAVLOVIĆ I., RELIĆ R. (2020): Prevalence of claw disorders in dairy farms with tie stall and loose housing system. Book of abstracts of 19th International conference „Life Sciences for Sustainable Development“, September, 24– 25, Cluj-Napoca, Romania, 119.
- CLARKSON M.J., DOWNHAM D.Y., FAULL W.B., HUGHES J.W., MANSON F.J., MERRITT J.B., MURRAY R.D., RUSSELL W.B., SUTHERST J.E., WARD W.R. (1996): Incidence and prevalence of lameness in dairy cattle. *Veterinary Record*, 138, 563–567.
- DE JARNETTE J.M., DAY M.L., HOUSE R.B., WALLACE R.A., MARSHALL C.E. (2001): Effect of GnRH pretreatment on reproductive performance of postpartum suckled beef cows following synchronization of estrus using GnRH and PGF. *Journal of Animal Science*, 93, 1675–1682.
- DOGAN I., KONYALI A., TOLU C., YURDAK S. (2008): Diferent estrous protocols during the transition period in lactating turkish does following AI. *Acta Veterinaria (Belgrade)*, 58, 2–3, 259–266.
- GRIFFITHS B.E., GROVE WHITE D., OIKONOMOU G. (2018): A Cross-Sectional Study Into the Prevalence of Dairy Cattle Lameness and Associated

- Herd-Level Risk Factors in England and Wales. *Frontiers in Veterinary Science*, 5, 65. doi: 10.3389/fvets.2018.00065
- GRUBIĆ G., ADAMOVIĆ M. (2003): *Ishrana visokoproizvodnih krava*, Institut PKB Agroekonomik, Padinska Skela, Beograd, pp 200.
- HEINS B.J., HANSEN L.B. (2012a): Short communication: Fertility, somatic cell score, and production of Normande × Holstein, Montbéliarde × Holstein, and Scandinavian Red × Holstein crossbreds versus pure Holsteins during their first 5 lactations. *Journal of Dairy Science*, 95, 918-924.
- HEINS B.J., HANSEN L.B., DE VRIES A. (2012b): Survival, lifetime production, and profitability of crossbreds of Holstein with Normande, Montbéliarde, and Scandinavian Red compared to pure Holstein cows. *Journal of Dairy Science*, 95, 1011-1021.
- HRISTOV S., STANKOVIĆ B., ZLATANOVIĆ Z., RELIĆ R. (2016): The most prevalent lameness disorders in dairy cattle. *Proc. The International Symposium on Animal Science*, November 24-25, Belgrade-Zemun, Serbia, 301-309.
- MILJKOVIĆ V. (1994): *Reprodukcija i veštačko osemenjavanje goveda*, Univerzitet u Beogradu- Fakultet veterinarske medicine, Beograd pp 1-443.
- MORRIS C.A., BAKER R.L., HICKEY S.M., JOHNSON D.L., CULLEN N.G., WILSON J.A. (1993): Evidence of genotype by environment interaction for reproductive and maternal traits in beef cattle. *Animal Production*, 56, 1, 69-83; 37 ref.
- MÜLLING C.K.W., GREEN L., BARKER Z., SCAIFE J., AMORY J., SPEIJERS M. (2006): Risk factors associated with foot lameness in dairy cattle and a suggested approach for lameness reduction. *Proceedings of the 26th World Buiatrics Congress*, Nice, 118-129.
- NEMEŠ Ž. (2016): *Uticaj genetskih i negenetskih faktora na produktivnost mlečnih goveda*. Doktorska disertacija. Univerzitet u Beogradu, Poljoprivredni fakultet.
- PERIŠIĆ P., SKALICKI Z., PETROVIĆ M.M., BOGDANOVIĆ V., TRIFUNOVIĆ G. (2008): Simmentalska rasa u kombinovanoj i specijalizovanoj proizvodnji. XVIII Inovacije u stočarstvu, 27-28. novembar, Beograd. *Biotehnologija u stočarstvu*, 24 (posebno izdanje), 25-38.
- PERIŠIĆ P., SKALICKI Z., PETROVIĆ M.M., BOGDANOVIĆ V., RUŽIĆ-MUSLIĆ D. (2009): Simmental cattle breed in different production systems. 9th Interantional Symposium "Modern Trends in Livestock Production" Belgrade, October 7-9, *Biotechnology in Animal Husbandry*, 25, 5-6, Book 1, 315-326.
- PERIŠIĆ P., SKALICKI Z., BOGDANOVIĆ V. (2012): Changes in the cattle sector in EU with possible effect on dairy and beef production in Serbia. *Proceedings of The first International Symposium on Animal Science*, November 8-10, Belgrade, 1-14.
- PERIŠIĆ P., BOGDANOVIĆ V., MEKIĆ C., RUŽIĆ-MUSLIĆ D. (2014): Simmental breed production characteristics and breeding goals. II International Symposium on Animal Science, September 23-25, Belgrade, Serbia, 17-24.

- PERIŠIĆ P., MALETIĆ M., MEKIĆ C. (2016): Possibilities for Improving Reproductive Traits in Cow-Calf System. Invited paper. Proceedings of the International Symposium on Animal Science (ISAS), November 24-25, 13-24.
- RADOJIČIĆ B., MATARUGIĆ D., SAVIĆ Đ., KASAGIĆ D., DESPOTOVIĆ D. (2009): Preveniranje proizvodnih bolesti visokomlečnih krava. *Agroznanje*, 10, 4, 159-169.
- RELIĆ R., RADENKOVIĆ-DAMNJANOVIĆ B. (2009): Biosigurnosne mere u kontroli bolesti papaka mlečnih krava. Zbornik referata 8. Kongresa veterinara Srbije sa međunarodnim učešćem, 15-19. septembar, Beograd, 129-134.
- RELIĆ R., VUKOVIĆ D., MIOČINOVIĆ J. (2015): Incidence of claw diseases and reproductive problems in dairy cows in Serbia. *Health, Welfare and the Lameness/Reproduction Interface. Proceedings of the Second DairyCare Conference*, March 3-4, Cordoba, Spain, 39.
- SOMERS J.G., FRANKENA K., NOORDHUIZEN-STASSEN E.N., METZ J.H. (2005): Risk factors for digital dermatitis in dairy cows kept in cubicle houses in the Netherlands. *Preventive Veterinary Medicine*, 71, 11-21.
- STOJIC P., BOJKOVIĆ-KOVAČEVIĆ S., BESKOROVAJNI R., JEREMIC I., PANTELIC V. (2012): Uzroci izlučenja krava u vezanom sistemu držanja. *Biotechnology in Animal Husbandry*, 28, 4, 697-704.
- TOHOLJ B., STEVANČEVIĆ M. (2015): Dijagnostika hromosti domaćih životinja. Univerzitet u Novom Sadu, Poljoprivredni fakultet, pp 106.
- VAKANJAC S., MALETIĆ M. (2013): Manipulacija polnim ciklusom krava. Zbornik predavanja 34 seminara za inovacije znanja veterinara, 8. februar, Beograd, 141-149.
- VUKOVIĆ D., MALETIĆ M., PAVLOVIĆ M., PAVLOVIĆ V. (2011): Primena i terapijski efekti hormona u reprodukciji krava. Zbornik predavanja, Naučni simpozijum „Reprodukcija domaćih životinja“, 13-16. oktobar, Divčibare, Srbija, 39-51.
- VUKOVIĆ D., PERKOVIĆ S. (2012): Veštačko osemenjavanje, plodnost i neplodnost goveda, Beograd, pp 1-176.
- WEBER A., STAMER E., JUNGE W., THALLER G. (2013): Genetic parameters for lameness and claw and leg diseases in dairy cows. *Journal of Dairy Science*, 96, 3310-3318.
- WHAY H.R., MAIN D.C., GREEN L.E., WEBSTER A.J. (2003): Assessment of the welfare of dairy cattle using animal-based measurements: direct observations and investigation of farm records. *Veterinary Record*, 153, 197-202.