Bulgarian Journal of Veterinary Medicine, 2025 ONLINE FIRST
ISSN 1311-1477; DOI: 10.15547/bjvm.2025-0043

Original article

PREVALENCE OF METABOLIC DISEASES IN THE POST-PARTUM PERIOD AND THEIR IMPACT ON MILK YIELD IN HOLSTEIN COWS

D. JANEVSKI[1], M. RADINOVIĆ[1], J. KRIVOKAPIĆ[1], Z. GACOVSKI[2], P. DODOVSKI[2], B. PETROVSKA[2], P. DAMESKI[2], I. ZDRAVESKI[2] & N. PETROVSKA[2]

[1]Department of Veterinary Medicine, Faculty of Agriculture, University of Novi Sad, Novi Sad, Serbia; [2]Faculty of Veterinary Medicine, "St Kliment Ohridski" University, Bitola, North Macedonia

Summary

Janevski, D., M. Radinović, J. Krivokapić, Z. Gacovski, P. Dodovski, B. Petrovska, P. Dameski, I. Zdraveski & N. Petrovska, 2025. Prevalence of metabolic diseases in the postpartum period and their impact on milk yield in Holstein cows. *Bulg. J. Vet. Med.* (online first).

Inadequate preparation of cows' diets during the dry and peripartum periods for the upcoming increased needs in milk production postpartum leads to the emergence of a negative energetic and mineral imbalance. In order to provide the necessary energy, especially the level of glucose in the blood and minerals, necessary for the synthesis of milk, physiological and endocrinological changes in the cows' body lead to the mobilisation of energy reserves, and the activation of glycogenolysis, gluconeogenesis and lipolysis. If the negative balance is more pronounced and lasts for a longer period of time, metabolic diseases occur in cows. The aim of the study is to assess the prevalence of metabolic diseases in the postpartum period and their impact on milk yield. The research included 237 Holstein cows divided into two groups. The first group of 189 cows that were examined for metabolic diseases, in which 48 cows (25.4%) had metabolic diseases. Puerperal paresis was the most common disease that occurred in 17 cows (35%), ketosis in 15 cows (31%), subacute rumen acidosis in 8 cows (17%), atypical puerperal paresis in 5 cows (11%) and osteomalacia in 3 cows (6%). The second group consisted of 48 healthy control cows, for which data were collected on the amount of milk during the lactation period. The study findings revealed that during the lactation period metabolic diseases reduced milk yield by 26.62%, or 7.96 L/milk per day, compared to a healthy population of cows.

Key words: Holstein, ketosis, osteomalacia, puerperal paresis

INTRODUCTION

The postpartum period in cows is characterised by increased demand of substances necessary for milk synthesis. During this period, milk production increases sharply in order to provide sufficient quantities for the calf's nutrition. To achieve this, the

body must become adapted to the newly created situation, which consists of increased food intake, increased ability to absorb nutrients, water and minerals. Endocrinological and physiological changes occur to meet the increased energy needs in the body of high-milk cows (DeGaris & Lean, 2008). These changes aim to mobilise the energy reserves in the animal's body, in order to maintain the required level of glucose in the blood. Thus, the rates of glycogenolysis, gluconeogenesis and lipolysis and acetate utilisation increase, while the rate of lipogenesis decreases (Sundrum, 2015).

If the body does not adapt to in a timely manner, metabolic disorders occur, which are especially pronounced at the beginning of the lactation period (Thomas & Herd, 2000).

Puerperal paresis is a disease that occurs immediately after calving and is characterised by hypocalcemia, hypophosphatemia, poor circulation, paresis of the striated muscles, and impaired consciousness. It occurs as a result of a decrease in blood concentrations of calcium and inorganic phosphorus due to loss through colostrum, while the body is unable to replace them through intestinal resorption or mobilisation from the bones. Calcium loss through milk amounts to 1–1.5 g of calcium (1–2 g in colostrum) and 0.8–1.2 g of phosphorus (0.9–1.8 g in colostrum) per liter (Flores *et al.*, 2022).

A few hours after birth, a physiological decrease in calcium concentration occurs to 1.7–2.1 mmol/L, and a decrease in inorganic phosphorus to 1–1.6 mmol/L, as compared to the normal value 2.1–3 mmol/L for calcium and 1.6–2.3 mmol/L for inorganic phosphorus. These low calcium and phosphorus levels are maintained for a maximum of 1–2 days (Garrett *et al.*, 2004). Paresis occurs when the calcium value decreases below 1.7 mmol/L, phosphatemia may remain at the same level or decrease, while magnesium may decrease or increase slightly (Bzuneh *et al.*, 2020). Affected cows often exhibit delayed initiation of lactation, reduced peak milk yield, and shortened lactation due to early culling or prolonged recovery time. Additionally, systemic weakness and impaired feed intake further exacerbate energy deficits.

Ketosis occurs as a result of impaired metabolism of carbohydrates and fatty acids when there is a negative energy balance, with the majority of disorders occurring in the liver, where the glycogenesis is intensified. The reason for the occurrence of ketosis is the decreased concentration of oxaloacetate, which is an intermediary substance in the processes of gluconeogenesis and the tricarboxylic acid cycle with a central role in intermediary metabolism (Bauer & Jagusiak, 2025). Oxaloacetate plays a role in the production of glucose and fat metabolism, where it participates in the breakdown of acetyl coenzyme A, formed from free fatty acids. IN case of oxaloacetate deficiency, the resulting acetyl coenzyme A is converted into ketone bodies (acetone, acetoacetate and beta-hydroxybutyric acid), which are excreted through the blood into milk (Garrett *et al.*, 2004).

Ketosis is characterised by hyperketonemia, ketonuria, hypoglycaemia, and decreased liver glycogen concentration (Drackley *et al.*, 1992). It is associated with a significant drop in milk yield up to 20–30% in severe cases. Subclinical ketosis also exerts negative effects on milk composition, particularly decreasing milk protein content and increasing milk fat-to-protein ratio (Martens, 2023).

Subacute rumen acidosis is a metabolic disease in dairy cows accompanied

by a decrease in the rumen pH value of the below 5.5. The disease is secondary to an unbalanced diet with a large amount of carbohydrates that have a negative impact on the rumen microbiota(Coco *et al.*, 2021). The pathogenesis of the disease consists in the replication of large quantities of lactic bacteria that release lactic acid in the rumen and change the normal pH environment. Lactic acid is detrimental for the rumen mucosa, penetrating and damaging the capillaries where it can induce laminitis, in addition to damage to the liver, heart, lungs, kidneys and other organs. Changes are most often observed two months after parturition, and a decrease in rumen pH below 5.5 leads to a reduction in milk yield as well as a lower percentage of milk fat (Elmehadi *et al.*, 2022).

Atypical puerperal paresis is a pathological condition that occurs 2–3 days after calving in highly yielding dairy cows. Cows lose the ability to stand up and lie down for a long time. The causes of this disease are complex and most often come down to disorders in mineral metabolism, traumatic diseases of the bones, nerves and muscles. Affected cows lose minerals through milk on average 44.6 mmol/L, especially phosphorus and sodium while during calving, the concentration of potassium in the blood serum drops from 4.6-6.4 mmol/L to 2.5-4.6 mmol/L (Flores *et al.*, 2022). Certain cases are associated with hypoproteinemia, which occurs due to reduced protein intake during pregnancy or possible proteinuria.

The difference between atypical and typical puerperal paresis is in the concentration of minerals (Garrett *et al.*, 2004). In typical puerperal paresis, there is a significant decrease in calcium concentration and a slight increase in magnesium while in atypical puerperal paresis, the decrease in calcium and magnesium levels is small, while the decrease in inorganic phosphorus and potassium is pronounced (Bzuneh *et al.*, 2020).

Osteomalacia is a demineralisation with hyperplastic osteodystrophy of the skeleton in dairy cows during pregnancy and lactation. The disease occurs as a result of reduced dietary phosphorus intake and increased calcium values (Garrett *et al.*, 2004). The etiology of osteomalacia is also influenced by the lack of vitamin D and protein. During lactation, the body is particularly stressed and osteomalacia develops intensively and rapidly. The course and signs of the disease appear faster if calcium intake is increased. Osteomalacia is characterised by demineralisation of the bone substance and increased production of non-calcified osteoid tissue in the bones, whereby the skeleton loses its strength while the bones and joints are sensitive to pain, so that at low loads the bones crack and break. Osteomalacia is distinguished by hypophosphatemia and problems in production and reproduction (Schild *et al.*, 2023). In terms of production, cows with osteomalacia exhibit lower lactation yields, partly due to reduced mobility, decreased feed efficiency, and increased metabolic strain. The condition often leads to premature culling, thus shortening the productive lifespan of the animal.

The aim of the research was to prove the percentage representation of metabolic diseases after calving in cows and by applying comparative analyzes of a healthy population of cows to calculate the impact of each disease separately on milk yield during one lactation period.

MATERIALS AND METHODS

The research and the provision of blood, milk and urine samples from animals was approved by the Ethics Committee of the Ministry of Agriculture, Forestry, Water Management and Veterinary Administration of the Republic of Serbia, Belgrade, on 11 April 2024, with number 001328298 2024 14841 002 001 323 022.

For the purposes of this study, two groups of Holstein-Friesian cows, 3–6 years of age, were included and evaluated through a two-phase methodological approach. The first phase involved clinical monitoring and diagnostic assessment of cows in the early postpartum period to identify the presence of metabolic diseases. The second phase entailed collection and analysis of milk yield data over the course of one full lactation period for all animals in both groups.

The first group consisted of 189 cows, all examined during the postpartum period for signs of metabolic disorders. Among these, 48 cows (25.4%) were diagnosed with specific metabolic diseases. For all cows in this group, milk production data were recorded throughout one standard lactation cycle.The second group served as healthy control group, comprising 48 cows with no clinical or subclinical evidence of metabolic or other systemic diseases. These animals were matched in number to the subgroup of cows diagnosed with metabolic disorders from the first group, to enable a comparative evaluation of milk yield performance in relation to metabolic health status. Milk yield data were likewise collected across the full lactation period. Both groups of cows were raised on the same farm, fed the same food, raised in a tied housing system under the same hygienic conditions.

The diagnosis of puerperal paresis was performed by determining the concentration of calcium, inorganic phosphorus, and magnesium in the blood serum. Blood samples were collected within 12 to 24 hours after delivery by puncture of the coccygeal vein. The sampling site was previously disinfected with an antibacterial agent and the blood was collected in tubes. Blood analyses were performed in an accredited biochemical laboratory. Puerperal paresis was diagnosed in mothers whose serum calcium was < 1.7 mmol/L or < 8.0 mg/dL (Flores *et al.*, 2022).

The diagnosis of ketosis in the milk was made using the Rother-Ross test for the presence of acetone and acetoacetate. The method is performed with milk to which an alkaline solution of sodium nitroprusside is added, which results in a positive reaction with a colour change from red to purple. This method can detect 1–5 mg/dL acetoacetic acid and 10–20 mg/dL acetone (Bauer & Jagusiak, 2025).

The proof of ketosis through the urine was by applying Lestradet's test to prove ketone bodies, acetone and acetoacetate.The procedure was performed by the Lestradet's test with a powdered reagent of sodium nitroprusside (1 g), ammonium sulfate (20 g) and sodium carbonate (20 g). on a white porcelain plate where the reagent is placed and 2–3 mL of urine were added.In all four cases, if the throat was positive for ketosis, a pink (+), dark pink (++), purple (+++) and dark purple (++++) colour developed within one to three minutes depending on the amount of ketone bodies in the urine. If the throat was negative for ketosis, a gray-green colour will appear (Drackley *et al.*, 1992).

The diagnosis of subacute rumen acidosis was performed by determining the pH value of the rumen contents (Elmehadi *et al.*, 2022). A sample was taken by ruminocentesis and a rumen probe, within 2 to 4 hours after the cows' meal. The contents sample was then placed on indicator paper for measuring the pH in the range of 2 to 12. Samples with a pH value below 5.5 were considered positive for subacute rumen acidosis (Garrett *et al.*, 1999). The procedure was confirmed twice for each cow two days after the first test. In cows with a pH value lower than 5.5 in both tests, a final diagnosis of subacute rumen acidosis was made (Coco *et al.*, 2021).

The diagnosis of atypical puerperal paresis was made by determining the blood serum concentrations of inorganic phosphorus and potassium in blood samples taken by puncture of the *v. coccygea* within 12 to 24 hours after delivery. The blood sampling site was previously disinfected with an antibacterial agent and the blood was collected in sterile tubes. Blood tests were performed in an accredited biochemical laboratory. Atypical puerperal paresis was diagnosed in the animals in which the blood serum phosphorus was below <1.5 mmol/L, while the potassium was <2.5 mmol/L. The urine of these animals was examined for proteinuria in the definitive diagnosis of this disease (Bzuneh *et al.*, 2020).

The diagnosis of osteomalacia was performed by biochemical analysis of the blood serum inorganic phosphorus . The blood was obtained from the tail vein. The concentration of phosphorus in healthy cows is 1.6–2.2 mmol/L, while for pathological concentration the value is below 1.3 mmol/L, and in severe cases of osteomalacia reaches a value of 0.65 mmol/L. In cows in which the values of inorganic phosphorus were below 1.3 mmol/L, an X-ray examination was performed. Radiographic changes in the bones were proven by changes in skeletal demineralisation, subperiosteal cortical bone resorption, deformities of the long bones, loss of the lamina dura dentes. Radiographic evidence of changes in the caudal vertebrae is a clear sign of osteomalacia, with appearance of indistinct contours of the vertebrae with poor contrast. Another way to confirm osteomalacia was bone biopsy of the ribs, sacrum of the pelvis, and tail vertebrae, where histological examinations of bonestructure were conducted. The degree of ongoing bone mobilisation was determined using the bone biomarker hydroxyproline, an amino acid that is released in the blood during the period of bone mineralisation (Schild *et al.*, 2023).

The obtained results were statistically processed using the SPSS software version 19.0 for Microsoft Windows, in which descriptive statistics were performed to determine the percentage of metabolic diseases in the studied samples. Using the TIBCO data Statistica program, analyses of variability in milk yield and ANOVA test for comparison of the average milk yield for the studied groups of cows were performed.

RESULTS

Out of the 189 examined cows in the first group, 48 cows or 25.4%, had metabolic disease in the postpartum period.

The most prevalent disease (Fig. 1) was puerperal paresis, which occurred in 17 cows (35%). Ketosis was diagnosed in 15 cows (31%), subacute rumen acidosis – in 8 cows (17%), atypical puerperal paresis – in 5 cows (11%) and osteomalacia – in 3 cows (6%).

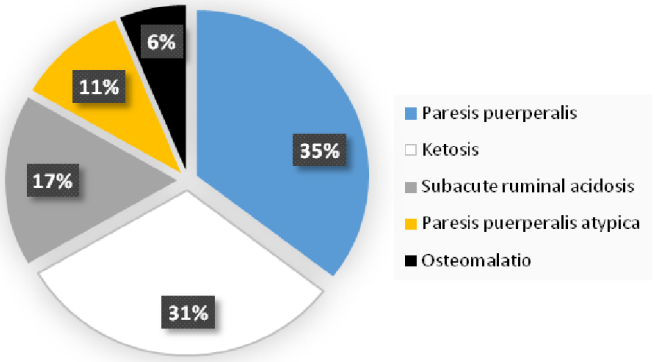

Fig. 1. Percentage of metabolic diseases in cows in the postpartum period.

Table 1. Data on the average daily yield of milk for both groups of cows in the researched lactation period

	Average milk yield during the lactation months, L/day										Average milk, L/day
	1	2	3	4	5	6	7	8	9	10	
Cows with metabolic diseases (n=48)											
Puerperal paresis (n=17)	13	23	24	29	27	25	24	21	20	18	22.4
Ketosis (n=15)	12	25	27	31	30	28	27	25	24	19	24.8
Subacute rumen acidosis (n=8)	19	29	31	32	31	30	28	26	25	22	27.3
Atypical puerperal paresis (n=5)	8	18	24	26	25	23	22	22	21	17	20.6
Osteomalacia (n=3)	6	11	13	16	20	19	18	17	14	12	14.6
Healthy cows (n=48)											
	31	32	34	36	33	31	28	27	24	23	29.9

The greatest decrease in milk yield occured in the first month of lactation, as a result of metabolic diseases in the postpartum period. The largest decrease in milk yield was observed in cows with osteomalacia with an average amount of 6 L/day in the first month of lactation and 12 L/day in the last month of the lactation period, with an average milk yield of 14.6 L/day for the entire lactation period. The smallest decrease in milk yield was observed in cows with subacute rumen acidosis with an average amount of 19 L/day in the first month and 22 L/day in the last month of the lactation period. The average milk yield in these cows was 27.3 L/day of milk for the entire lactation period. The average milk yield in a healthy population of cows was 31 L/day in the first month and 23 L/day in the last month of the lactation period. The average milk yield for the entire lactation period was 29.9 L/day of milk.

Table 2 shows the milk yield values for the group of cows with metabolic diseases and the control group of healthy cows. The minimum milk yield in cows with metabolic diseases was 6.11 L/day, while the maximum yield was 31.67 L/day, while in the control group the minimum and maximum daily milk yields were 23.83 L/day, and 36.43 L/day, respectively.

Table 2. Average milk yield during the lactation period in cows with metabolic diseases and healthy group of cows

Group of cows	Mean ± SD	Min–max	CV %
Cows with metabolic diseases	21.94 ± 6.87	6.11–31.67	26.62
Control group	29.90 ± 3.72	23.83–36.43	10.11

The one-factor analysis of variance demonstrated statistically significant difference ($P<0.05$) in milk yield between the two groups of cows. There was a significant differences in milk yield between the studied groups. The group of cows with metabolic diseases showed significantly higher variability in milk yield of 26.62%, while the percentage in the control group was 10.11%.

DISCUSSION

The aim of the research was to determine the prevalence of metabolic diseases in the postpartum period and their impact on milk yield in Holstein cows. The postpartum period is characterised by a sharp increase in milk synthesis. In the postpartum and the early lactation periods, about 50–60% of the total amount of milk secreted during the lactation period is produced. During this period, cows that do not receive the necessary energy through food, consume their own energy reserves and then develop a negative energy balance and metabolic diseases (Sundrum, 2015).

In the conducted research, out of a total of 189 cows examined, 48 cows (25.4%) had developed a metabolic disease, which represents a quarter of the examined samples. Similar results were obtained in the research of Garrett & Oetzel (2004).

The research indicates a high rate of metabolic diseases in the postpartum and the early lactation periods. The most prevalent disease was puerperal paresis (35%). This high incidence underscores the physiological challenges related to calcium homeostasis at the onset of lactation and corroborates previous findings that hypocalcemia is one of the most common metabolic disorders in dairy herds (Flores *et al.*,2022). In 15 cows (31%) ketosis was diagnosed as the second most prevalent disease, reflecting the widespread occurrence of negative energy balance in early lactation, which coincides with the research conducted by (Flores *et al.*, 2022). Subacute rumen acidosis was diagnosed with a prevalence of 17% (8 cows); similar results regarding the prevalence of this disease are shown by Thomas & Herd (2020). Atypical puerperal paresis was diagnosed in 5 cows (11%). This represents a significant percentage in which this disease should not be equated with puerperal paresis primarily due to the etiology of occurrence and the application of appropriate therapy. Osteomalacia was diagnosed in 3 cows or 6% of the total disease percentage , which has the closest results to the research conducted by Bzuneh *et al.* (2020). Despite its lower prevalence, osteomalacia was associated

with the most pronounced reduction in milk production, highlighting its severe impact on both skeletal integrity and metabolic function.

The analysis of milk yield patterns revealed a statistically significant difference ($P<0.05$) between the group of cows with postpartum metabolic diseases and the healthy control group. These findings reflect the significant negative impact of metabolic diseases not only on average production levels but also on the overall productive potential of affected animals. Furthermore, the variability in milk yield was markedly higher in the group with metabolic diseases, as evidenced by a coefficient of variation of 26.62%, compared to 10.11% in the healthy control group. Theincreased variability suggests greater inconsistency in lactational performance among affected animals, likely due to disease severity, delayed diagnosis, and variability in response to treatment. In contrast, the healthy group demonstrated more stable and predictable milk production dynamics. Examining the temporal distribution of milk yield, the negative effect was especially pronounced in the first month of lactation, where the average amount of milk was 11.6 L/ day for all metabolic diseases, compared to the healthy population with average yield for the first month of 31 L/day. This difference of 19.4 L/day (62.5%) compared to the healthy cows determining the negative impact of metabolic diseases on milk yield, confirmed by the results of previous research (Gross & Bruckmaier, 2019).

The present study determined an increase in milk yield as early as the second month of the lactation period, yet with significantly lower milk quantities compared to the healthy population of cows and the impact of each metabolic disease separately on milk yield for the entire lactation period compared to the healthy population of cows. The healthy control group demonstrated a more typical lactation curve, with high initial yields (31 L/day) that gradually declined toward the end of the lactation period (23 L/day), consistent with physiological expectations for lactation persistency in Holstein cows. The relatively lower final yields in diseased cows may also reflect premature drying-off or ongoing subclinical issues.The puerperal paresis reduces milk yield by 25.08% or 7.5 L/day on the average , which in terms of comparative research is most similar to the results of Bzuneh *et al.* (2020). In ketosis, the reduction was 5.1 L/day (reduction by 17.06%) as confirmed by Bauer & Jagusiak (2025). Subacute rumen acidosis caused a decrease in milk yield by 2.6 L/day (8.7%) comparable to the results of Elmehadi *et al.* (2022).Atypical puerperal paresis reduced milk yield by 9.3 L/day, i.e. by 31.1%, which confirmed data reported by Bzuneh *et al.* (2020).
Osteomalacia reduced milk yield by 51.17% (15.3 L/day), as previously affirmed by Schild *et al.* (2023).

The variability in milk yield in cows with metabolic diseases compared to the healthy cow population was 26.62%, i.e. with the impact of metabolic diseases, milk yield was reduced by 26.62% or by 7.96 L/milk per day compared to the healthy cow population, during the lactation period (Coco *et al.*, 2021).

CONCLUSION

The results of this study clearly demonstrate the substantial unfavorable impact on milk production in dairy cows suffering from metabolic disorders in the postpartum period. A significant propor-

tion (25.4%) of examined Holstein cows were diagnosed with a metabolic disorder in the postpartum period.

Puerperal paresis and ketosis were the most prevalent, while osteomalacia caused the most significant decline in milk production. The reduction in daily milk yield associated with the occurrence of metabolic disorders in the examined cows highlights the critical physiological challenges faced by dairy cows during the transition period, from pregnancy to peak lactation. On average, cows with metabolic disorders produced 7.96 liters less milk per day compared to healthy cows with statistically significant differences between the two groups.

The results highlight the importance of cows' metabolic health during this transition period. Proactive and effective management through standardised nutrition, regular monitoring, and early intervention is of pivotal meaning to support their recovery and ensure steady milk production.

REFERENCES

Bzuneh, E., T. Alemneh & M. Getabalew, 2020. Milk fever (parturient paresis) and its economic impact in dairy cattle production. *Journal of Veterinary Medicine and Research*, **7**, 1–8.

Bauer, E. A & W. Jagusiak, 2025. Prediction of ketosis using radial basis function neural network in dairy cattle farming. *Journal of Preventive Veterinary Medicine*, **235**, 106410.

Coco, R., M. E. A. Canozzi & V. Fischer. 2021. Rumination time as an early predictor of metritis and subclinical ketosis in dairy cows at the beginning of lactation: Systematic review-meta-analysis. *Journal of Preventive Veterinary Medicine*, **189**, 105309.

DeGaris, P. J. & I. J. Lean, 2008. Milk fever in dairy cows: A review of pathophysiology and control principles. *The Veterinary Journal*, **176**, 58–69.

Drackley, J. K., M. J. Richard, D. C. Beitz & J. W.Young, 1992. Metabolic changes in dairy cows with ketonemia in response to feed restriction and dietary 1,3-butanediol. *Journal of Dairy Science*, **75**, 1622–1634.

Elmehadi, M. E., D. K. Ali, M. K. Khogali & H. Wang, 2022. Subacute ruminal acidosis in dairy herds: Microbiological and nutritional causes, consequences, and prevention strategies. *Journal of Animal Nutrition*, **10**, 148–155.

Flores, C. F. A., Z. C. Viaduri, P. H. Briano, R. R. L. Dominguez, M. A. L. Carlos, U. M. Cruz & L. A. Reyes, 2022. Hypocalcemia in the dairy cow. *Revista Mexicana de Ciencias Pecuarias*, **13**, 1025–1038.

Garrett, E. F., M. N. Pereira, K. V. Nordlund, L. E. Armentano, W. J. Goodger & G. R. Oetzel, 1999. Diagnostic methods for the detection of subacute ruminal acidosis in dairy cows. *Journal of Dairy Science*, **82**, 1170–1178.

Garrett, R. & D. V. M. Oetzel, 2004. Monitoring and testing dairy herds for metabolic disease. *Veterinary Clinics of North America: Food Animal Practice*, **20**, 651–674.

Gross, J. J. & R. M. Bruckmaier 2019. Review: Metabolic challenges in lactating dairy cows and their assessment via established and novel indicators in milk. *Animal*, **13**, 75–81.

Martens, H., 2023. Invited review: Increasing milk yield and negative energy balance: a gordian knot for dairy cows? *Animals*, **13**, 3097.

Sundrum, A., 2015. Metabolic disorders in the transition period indicate that the dairy cows' ability to adapt is overstressed. *Animals*, **5**, 978–1020.

Schild, C. O., F. M. Boabaid, L. G. S. Olivera, M. Macgado, A. Vildoza, A. Saravia, A. Custodio, C. Command, A. Martinez, M. Jaurena, R. Dixon & F. R. Correa, 2021. Costs of clinical mastitis with special ref-

erence to premature culling. *Journal of Veterinary Diagnostic Investigation*, **33**, 1018–1022.

Schild, C. O., F. M. Boabaid, L. G. S. Olivera, M. Macgado, A. Vildoza, A. Saravia, A. Custodio, C. Command, A. Martinez, M. Jaurena, R. Dixon, & F. R. Correa, 2023. Response of cows with osteomalacia grazing sub-tropical native pastures to phosphorus supplementation with loose mineral mix or feed blocks. *The Veterinary Journal*, **298**, 106013.

Thomas, H. & D. V. M. Herd, 2000. Ruminant adaptation to negative energy balance: influences on the etiology of ketosis and fatty liver. *Veterinary Clinics of North America: Food Animal Practice*, **16**, 215–230.

Paper received 18.04.2025; accepted for publication 06.08.2025

Correspondence:

Dejan Janevski,
University of Novi Sad,
Faculty of Agriculture,
Department of Veterinary medicine,
Trg Dositeja Obradoviča 8,
21101 Novi Sad, Serbia
e-mail: dejan95janevski@gmail.com