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Effect of mineral supplementation on incidence of reproduction disturbances and fertility parameters in Polish Holstein-Friesian cows

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ABSTRACT

The research was undertaken to determine the effect of the mineral mixture Bovifosfomag®, recipe-adapted to the biogeochemical conditions prevailing in the region of animal residence, on cow fertility and productivity. A two-year study was conducted with 96 multiparous Polish Holstein-Friesian cows (Black-and-White variety) in four farms located in eastern Poland. Herds with an average of 24 cows, were divided into two groups, i.e. control and treatment. Control group cows received no mineral mixture. Animals from the treatment groups received the Bovifosfomag® mineral mixture. The composition of the mix took into account the geobiochemical conditions of farm location. Cows were routinely checked by the veterinarian for reproductive problems. Health records included abortion, endometritis, anoestrus and paresis puerperalis. Fertility measures were calculated using calving dates and insemination dates and included: first service pregnancy rate, gestation interval, calving interval, insemination index and fertility status. The analysis of fertility indices and clinical diseases of the reproductive system showed that there was a significant decrease in fertility of the studied animals. Mineral nutrition is given a special role in cow fertility. It was found that it is possible to affect the improvement in mineral supply of cows by including a mineral additive in the form of Bovifosfomag® mixture in the dietary dose. A positive effect of the mineral mixture on the reproductive indices and a decrease in the incidence of clinical forms of reproductive diseases was found. This indicates the advisability of the mineral mixture of the proposed component composition used in the experiment.

Keywords: Dairy cows, Fertility, Mineral supplementation, Reproductive disorders

Maintaining the physiological balance of the reproductive function of cattle depends to a large extent on proper mineral supply (Esposito *et al.* 2014). Trace elements act as cofactors with important roles in hormone and biochemical processes associated with reproduction (Jalali *et al.* 2020).

Reproductive disorders occur at high frequency among health problems in dairy cattle breeding (Jesse *et al.* 2019). These diseases can affect the overall productivity of dairy cows by reducing milk yield (Ashoo *et al.* 2020). Not only proper mineral nutrition of ruminants depends largely on the mineral abundance of soil and plants grown on it but also the degree of mineral component assimilability by the animal organism, as well as mutual synergistic or antagonistic interactions between ions of particular macro- and microelements (Yatoo *et al.* 2016, Ashoo *et al.* 2020). Commonly roughages and green fodder are deficient in minerals. Therefore, it is necessary to examine biogeochemical conditions and interactions between elements in the soil–plant–animal system (Kumar *et al.* 2020c). Deficiency of Fe, Cu, Zn, Mn and Se have been associated with decreased livestock fertility, growth and performance (Mokolopi *et al.* 2019).

In the previous study (Górski and Saba 2016, Górski *et al.* 2018) carried out in farms located in the eastern Poland, abnormalities were found in the mineral supply of cows, which was expressed by deficiencies of phosphorus, magnesium and selenium in the animal body. At the same time, there is a decrease in fertility in cattle living there, which may be related to irregularities in mineral management. Nutritional prophylaxis during the periparturient period has a primary role in herds (Satapathy *et al.* 2019). Complementing deficiencies in mineral supply can be achieved through the use of multicomponent mineral mixtures (Mohapatra *et al.* 2012, Górski and Saba 2015).

In connection with the registration of increased incidence of the reproductive system diseases in the investigated farms, research was undertaken to determine the effect of the mineral mixture Bovifosfomag®, recipe-adapted to the biogeochemical conditions prevailing in the region of animal residence, on cow fertility and productivity.

MATERIALS AND METHODS

A two-year study was conducted with 96 multiparous Polish Holstein-Friesian cows (Black-and-White variety)

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in four farms located in eastern Poland. In all farms, cows were housed in tie-stall barns. Herds with an average of 24 cows, were divided into two groups, i.e. control and treatment. Control group cows received no mineral mixture (Table 1). Animals from the treatment groups received the Bovifosfomag® mineral mixture. The composition of the mix took into account the geobiochemical conditions of farm location. The mixture was fed with concentrated feed in the amount of 150 g per head. It was introduced into nutrition gradually over a period of two weeks. The studies were carried out during summer and winter nutrition. At that time, cows were fed traditionally on maize silage, forage, and grass and legume haylage. Concentrate feed was allocated to feeding boxes depending on the individual milk yield. Dairy cows were grazed during the day from spring to autumn. Food needs of cows were established on the basis of feeding standards (NRC 2001). The cows were milked twice daily with a pipeline milking machine. Milk production performance of the animals were recorded. Cows were routinely checked by the veterinarian for reproductive problems. Health records included abortion, endometritis, anoestrus and paresis puerperalis. Artificial insemination with frozen bull semen were made by an AI technician. Pregnancy was diagnosed by per rectum examination. Fertility measures were calculated using calving dates and insemination dates and included: first service pregnancy rate, gestation interval, calving interval, insemination index and fertility status. Data are reported as mean±standard deviation. Analysis of the data was performed using the Statsoft Inc. software package STATISTICA ver. 12.0 PL. Statistical significance between mean values was calculated using Student's t-test. The level of significance was set at $P<0.05$.

RESULTS AND DISCUSSION

First service pregnancy rate is an indicator which determine the quality of artificial insemination in herds. The first service pregnancy rate of approximately 38% observed in this study in control groups (Table 2), was lower to that of animals from Maharashtra (Potdar *et al.* 2020). In this study after mineral supplementation, the average effectiveness of the first service pregnancy rate increased.

There were irregularities in the reproduction of cows from all farms. This was particularly evident in the unfavourable shaping of the gestation interval. This period should be 70–90 days in the conditions prevailing in Poland. In herds of cows from farms C and D, this indicator reached 121.2 and 125.0 days, respectively. It was slightly lower in farms A and B and amounted to 119.7 and 109.1 days, respectively. As a consequence of the mineral mixture addition, the gestation interval in cows from treatment groups was reduced by a few or even a dozen days. This concerned cows kept in all farms. The positive influence of mineral supplementation on the health condition of cow reproductive system is confirmed by the results of the research conducted by Srivara and Bhuvaneswari (2019).

A perfect calving interval for high reproductive performance of dairy cows with the average milk yield of about 7000 kg is 365 days (Houghton *et al.* 2000). Cattle reproduction is badly influenced by mineral deficiencies through prolonged calving intervals (Tiwary *et al.* 2010). Retention of placenta, metritis, pyometra, increased the incidence of embryonic loss and mineral imbalances may cause prolonged calving interval (El-Tarabany *et al.* 2016).

Table 1. Composition of modificated material of mineral mixture Bovifosfomag®

Specification	Content of pure element							
	(g)	Ca (g)	P (g)	Mg (g)	Na (g)			
$Ca(H_2PO_4)_2$ (calcium phosphate)	350	60	95	–	–			
$Ca_3(PO_4)_2$ (tricalcium phosphate)	100	39	20	–	–			
MgO (magnesium oxide)	175	–	–	105	–			
$CaCO_3$ (ground limestone)	200	80	–	–	–			
NaCl (forage salt)	175	–	–	–	70			
Total macroelements	1000	179	115	105	70			
Specification	Content of pure element							
	(g)	Zn (g)	Cu (g)	Fe (g)	Mn (mg)	Se (mg)	I (mg)	Co (mg)
$ZnSO_4.7H_2O$ (zinc sulfate)	22.000	5.0	–	–	–	–	–	–
$CuSO_4.5H_2O$ (cupric sulfate)	4.000	–	1.0	–	–	–	–	–
$FeSO_4.7H_2O$ (ferrous sulfate)	5.000	–	–	1.2	–	–	–	–
$MnCO_3$ (manganese carbonate)	0.020	–	–	–	10.0	–	–	–
Na_2SeO_4 (sodium selenate)	0.050	–	–	–	–	20.0	–	–
KI (potassium iodide)	0.040	–	–	–	–	–	30.0	–
$CoSO_4.7H_2O$ (cobalt sulfate)	0.015	–	–	–	–	–	–	3.0
Total microelements	31.125	5.0	1.0	1.2	10.0	20.0	30.0	3.0
Total	1031.125							

Table 2. Fertility parameters in examined cows

Parameter	Farm A		Farm B		Farm C		Farm D	
	Control group	Treatment group	Control group	Treatment group	Control group	Treatment group	Control group	Treatment group
Average milk yield	6214	6365	6184	6303	5966	6199	6401	6698
First service pregnancy rate (%)	31.9±3.0	34.2±4.3	34.6±3.2	38.7±4.4	36.7±3.3	37.7±4.5	47.6±3.8	50.3±5.7
Gestation interval (days)	119.7^{b}±65.50	103.8^{a}±35.63	109.1^{b}±75.10	105.4^{a}±41.20	121.2^{b}±64.39	107.6^{a}±38.67	125.0^{b}±69.01	115.7^{a}±35.80
Calving interval (days)	397.8±65.21	385.9±33.29	386.2±76.79	380.4±41.10	396.0±64.14	383.0±37.44	403.9±68.76	399.8±35.31
Insemination index	1.8±0.85	1.6±0.67	1.9±0.80	1.7±0.70	1.8±0.90	1.6±0.75	1.6±0.95	1.5±0.72
Fertility status	23.10^{a}±2.44	42.60^{b}±5.31	34.20^{a}±2.77	42.37^{b}±4.64	24.20^{a}±2.20	41.00^{b}±4.69	29.75^{a}±2.86	42.84^{b}±4.88

Means±SD; a, b, statistically significant differences at P<0.05.

In the present study, the shortest average calving interval was characteristic for cows from farm B, in which no additives were used (386.2 days), and the longest was in cows from farm D (403.9 days). In the present study, a positive effect of nutrient supplementation on the calving interval was observed. The calving interval was shortest for the cows from farm B receiving the Bovifosfomag® mineral supplement (380.4 days), and the longest for the cows from farm D (399.8 days) (P<0.05). Richards *et al.* (2019) observed that the poor mineral nutrition is one of the main factors resulted in an increase in calving interval.

In this study, the insemination index for cows from farms A, B and C was 1.8 on average in control groups. In cows from farm D, this indicator reached the value of 1.6, which corresponds to the reference values (De Kruif *et al.* 1998). The value of the insemination index largely depends on the level of insemination organization (Muller *et al.* 2014).

After supplementation of food doses with the mineral mixture, the insemination index ranged from 1.5 (farm D) to 1.7 (farm B) in cows from the treatment group. It can be assumed that the reason for the reduction of the insemination index value in cows from the treatment groups was the improvement of the reproductive health in animals receiving the mineral supplement.

Fertility status is a determinant for the overall assessment of herd fertility, with particular emphasis on the effectiveness of insemination. The correct value of this indicator should be >54 (De Kruif *et al.* 1998). Taking into account the results obtained in this study, it should be concluded that the level of this indicator in the control groups was too low. However, a tendency to improve it could be observed, which should be associated with the beneficial effects of the mineral mixture on the cow reproductive system health.

The use of mineral mixture caused a slight increase in milk yield in cows from the treatment groups. Supplemented cows produced an average of 3.1% more milk than the control cows. A similar effect was also observed by Gandra *et al.* (2014). It can be assumed that feeding of mineral mixture enhanced milk production due to the action of minerals, by stimulating the myoepithelial cells of the udder (Kumar *et al.* 2020c).

In connection with the registration of increased incidence of the reproductive system diseases in the investigated cows, the research was undertaken to determine the relationship between the improvement of mineral nutrition and the occurrence of clinical changes in the reproductive organ. As a result of nutritional mistakes made during the perinatal period, cows showed changes and pathological conditions such as: abortion, endometritis, anoestrus, paresis puerperalis, placental retention and uterine infections. During the perinatal period, the animal's organism is characterized by overload and dissociation of regulatory mechanisms, which is the result of physiological stress associated with parturition (Górski and Saba 2012, Kumar *et al.* 2021).

Table 3 contains data on the frequency of clinical forms of fertility disorders in cows in individual herds. The obtained results indicate the diversity of incidence and frequency of individual reproductive disorders in cows.

In the present study, anoestrus is the dominant problem. Anoestrus is one of the major causes of poor reproductive performance in cattle (Ashoo *et al.* 2020). In the present study, out of 48 cows tested in control groups, including all farms, as many as 15 animals had anoestrus-related disease symptoms. The severity of anoestrus in cows

Table 3. Incidence of reproduction clinical disturbances in cows from the studied farms prior and after the mineral mixture supply

Parameter	Farm A				Farm B				Farm C				Farm D				Total			
	Control group		Treatment group		Control group		Treatment group		Control group		Treatment group		Control group		Treatment group		Control group		Treatment group	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Sexual cycles observed	12	100	12	100	12	100	12	100	12	100	12	100	12	100	12	100	48	100	48	100
Abortion	1	8.3	0	0	1	8.3	1	8.3	2	16.6	1	8.3	0	0	0	0	4	8.3	2	4.15
Endometritis	1	8.3	0	0	2	16.6	1	8.3	4	33.3	2	16.6	1	8.3	0	0	8	16.6	3	6.22
Anoestrus	4	33.3	1	8.3	5	41.6	0	0	4	33.3	2	16.6	2	16.6	1	8.3	15	31.2	3	8.3
Paresis puerperalis	1	8.3	0	0	1	8.3	0	0	2	16.6	1	8.3	0	0	0	0	4	8.3	1	2.07

from control groups in the studied herds was 31.2% on average (16.6–41.6%). In cows, the reason for the weakening of estrus symptoms is energy deficiency at the beginning of lactation, which is accompanied by a limited release of gonadotropic hormones, impaired ovarian follicle growth and lower estrogen synthesis (Sethy *et al.* 2019). Khan *et al.* (2016) reported a high incidence of anestrus cases in dairy cattle raised in Odisha and North-Eastern India. Phosphorus is associated with energy metabolism and its deficiency results in anoestrus, repeat breeding and irregular estrous cycle (Selvaraju *et al.* 2009, Ali *et al.* 2014).

The abortion in cows from control groups occurred at low frequency. The average percentage of abortion in animals not receiving the mineral mixture was 8.3% (0–16.6%). In contrast to our study, Dawit and Ahmed (2013) observed relatively lower average prevalence (6.3%) of abortion. Deficiences in Ca, Mg, P, Cu, Se, Zn and Mn have been associated with occurrences of abortion in cows (Mokolopi 2019).

Among 48 cows, which did not receive any mineral mixture, symptoms of endometritis were recorded in 8 cows (16.6%). In herds A and D, two cases of this disease were recorded in tested animals from control groups. The same number of endometritis cases was observed in the control group from farm B. In herd C, the incidence of the disease in cows that did not receive the mineral mixture exceeded 33%. In earlier studies made in Poland, endometritis was found in about 5% (Barañski *et al.* 2012) and even in 40.2% of cows (Janowski *et al.* 2013). Cheong *et al.* (2011) reported 52.6% cases of endometritis in particular herds. Kumar *et al.* (2012) reported a low incidence of endometritis (9.09%) in buffaloes. In this study, the criterion for diagnosing this disease was a rectal and ultrasound examination of the uterus. In high-yielding cows, endometritis is reported as caused by energy deficiency weakening the uterine defensive forces. Endometritis can also occur as a complication of the correct course of the postpartum period. The infection with a pathogenic bacterium such as *T. pyogenes* increases the likelihood of endometritis developing (Bicalho *et al.* 2012). Paresis puerperalis was registered in 4 studied cows from control groups.

In dairy cows, the peripartum period is critical and present considerable physiological challenges to homeostasis by imposing significant metabolic stressors that may contribute to the onset of reproductive diseases. Antioxidant system helped by mineral supplementation can protect against oxidative stress which is the cause of several disorders (Castillo *et al.* 2005). Clinical cases of reproductive system diseases observed in the examined cattle herds may have been associated with mineral abnormalities in dairy cows. Supplementation of cow feeding doses with mineral mixture used in the experiment improved the mineral supply of animals and reduced the number of clinical cases of reproductive disorders. As shown in studies by Khalil *et al.* (2019) and Molefe and Mwanza (2019), there is a relationship between improving mineral nutrition and reducing the incidence of reproductive system diseases.

The percentage of cows with symptoms of reproductive system diseases in the treatment groups was lower than in the control groups. The cause of the paresis puerperalis is cation-anion imbalance in the body, which impairs the mechanisms responsible for maintaining normal blood calcium levels (Kimura *et al.* 2006). Supplementation with calcium preparations can prevent a significant proportion of paresis puerperalis cases when given to parturient cows (Thilsing-Hansen *et al.* 2002). Paresis puerperalis was recorded only in farm C in one cow receiving a mineral mixture supplement. When analyzing the incidence of reproductive clinical disturbances in cows after the mineral mixture supply, two cases of abortion were found in treatment groups from farms B and C. Mineral deficiency is associated with a wide range of health disorders in cattle. In pregnant animals, the deficiency of selenium leads to abortion (Yatoo *et al.* 2018). According to Giadinis *et al.* (2016), selenium deficiency resulted in an almost 50-fold increase in the probability for a cow to abort compared to the status after Se supplementation. According to Sheldon *et al.* (2009), a uterine disease is observed in up to 40% of dairy cows after parturition and from 37% to 75% of cows

develops endometritis (Knudsen *et al.* 2015). Coto and Lucy (2018) emphasize the necessity to detect and treat cows suffering from endometritis efficiently as soon as possible. The previous study suggested that supplementation with selenium diminish retained placenta, which also means less uterine infection and inflammation (Moeini *et al.* 2009). Machado *et al.* (2013) observed that trace mineral supplementation before and after calving reduced the incidence of endometritis. In the present study, a supplementation of mineral mixture decreased incidence of endometritis in cattle. Among 48 cows receiving a mineral mixture, 3 showed symptoms of endometritis. The same number of cases was found for anoestrus. The major etiological factor causing anoestrous in bovine is nutrition (Kumar *et al.* 2020b). The prevention of anoestrous can be achieved by providing minerals supplementations (Srivara and Bhuvaneswari 2019). For estrus induction, minerals such as calcium, selenium, zinc and copper should be supplemented (Verma and Kumar 2018, Kumar *et al.* 2020a). Noonari *et al.* (2016) observed that treatment of cows with provision of vitamin-mineral mixture suffering from postpartum anoestrus came in heat with 100% results.

The analysis of fertility indices and clinical diseases of the reproductive system showed that there was a significant decrease in fertility of the studied animals. There are many factors that affect cow fertility. Mineral nutrition is given a special role in this respect. It was found that it is possible to affect the improvement in mineral supply of cows by including a mineral additive in the form of Bovifosfomag® mixture in the dietary dose. A positive effect of the mineral mixture on the reproductive indices and a decrease in the incidence of clinical forms of perinatal diseases was found. This indicates the advisability of the mineral mixture of the proposed component composition used in the experiment.

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