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HIGH SPERM PRODUCTION AS RELATED TO MACRO- AND MICROELEMENT LEVELS IN BLOOD SERUM IN SERVICING BULLS OF THE MODERN SELECTION

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A b s t r a c t

Nowadays in commercial animal husbandry the intensive metabolizer genotypes are basically used. In such a case the animal health and performance should be characterized neither by the presence or absence of clinical manifestations of diseases, nor by decreased productivity or reproductive ability, but by the parameters of metabolism and its early violations at a subclinical level. Herein we summarize original data on the levels of the essential macroelements, in particular Ca, P, Mg, Fe and chlorides, and microelements, the Cu, Zn, Se and Mn, in blood serum of the superior sires as influenced by their age, beef or milk specialization and RED-factor expression. In our experiment the 2-7 year meat Aberdeen Angus, Herefordm, Lymousine cattle, milk Red-and-White Holsteine, Black-and-White Holsteine, Ayrshire cattle, and also universal Brown Swiss cattle were assessed (n = 49 in total). The following parameters were investigated: an ejaculate volume, the spermatozoid number per ml, the percentage of spermatozoid motility in the native, diluted, frozen and thawed semen, and in the samples frozen, thawed and then incubated at 38 °C for 5 hours. The total spermatozoid number per ejaculate, semen dose number per each sire, frozen semen dose number sampled during 24 hour, and the percentage of culled native ejaculates were also assessed. It was shown the microelements to influence the semen quality and quantity. Macro- and microelement levels in the sires' blood serum were shown to depend manly on the diet and should be constantly controlled and adjusted. According to the obtained data, the differences in macro- and microelement levels due to specialization and RED-factor expression are unreliable, while the changes in Ca:P ratio and Cu, Zn and chloride levels in blood serum influence the semen quality in the bull sires. Our data suggest that in each cattle breed the physiological standard levels of macro- and microelements in blood serum should be revised with respect to age, sex, physiological condition, a season, livestock farming technology and specialization. Besides, the data confirm the need for an integrated control and adjustment of animal supply with macro- and microelements referring to their deficit or excess in different geochemical provinces.

Keywords: microelements, macroelements, bull sires, sperm production, breeding.

Nowadays in commercial animal husbandry animal health considered the most essential for the their exploitation.

In milk production the significant genetic progress for 20 past years is due mainly to wide use of artificial insemination and multiplication of the valuable genotype with specifically high metabolic activity. In such a case the animal health and performance should be characterized neither by the presence or absence of clinical manifestations of diseases, nor by decreased productivity or reproductive ability, but by the parameters of metabolism and its early violations at a subclinical level (1). Biochemical assays allow to control early disturbances in metabolism of proteins, carbohydrates, lipids, vitamins, macro- and microelements, and the more violation found, the more crucial disorders occur (1).

Verification of performing and reproductive health in cows of new genotypic formation aimed to intensification of their commercial use necessitates the detailed metabolic examinations of both parents, and moreover, the physiological status of the most valuable bull sires must be under special consideration (2). Besides, slight metabolic disorders in young animals can indicate the genetic abnormalities (3).

The 15 microelements, namely Fe, I, Cu, Zn, Co, Se, Mn, Cr, Ni, V, Mo, F, Li, Si and As, are essential. They are involved in cell receptors and transfer proteins, influence the activity of enzymes and hormones as well as their synthesis, have an antioxidant effect and an impact on immune response, etc. (4, 5).

Metabolic disorders may occur both at deficit or excess of some elements. The same or very similar skeletal diseases were detected at Ca, P, Cu, Mn, Zn, Si, vitamin A and D deficit, as well as at Mo, F, Sr and vitamin D excess. Anemia is caused by deficit of Fe, Cu, Co or some vitamins or by Mn, Vo, Zn, Cu, Pb, Se excess in the animal diet (6).

It is commonly known that micro- and macroelements are involved in the regulation of basic physiological processes. Particularly, Ca is accumulated in skeletal tissues, but also is involved into regulation and different vital processes in cells and tissues. Ca level in blood of healthy animals depends on Ca, P, Mg and vitamin D in the ration. Of total mineral compounds in animal body Ca and P make 70-75 %. At that about 90-99 % of Ca and 80-87 % of P are in the skeleton, while the soft tissues contain 1-2 % and 13-20 %, respectively. Ca and P deficit leads to osteomalacia or osteoporosis in adults. Calcium ions are essential for blood coagulation, colloid structure of proteins and membrane permeability, resistance to infectious diseases and toxic agents. It contributes to a decreased nervous irritability, regulation of hart function and activation of adrenocortical hormones, pituitary hormones and pancreatic hormones (7). P is involved in different biochemical reactions, particularly in energy transfer, as well as in metabolism and transfer of lipids and carbohydrates. P is a component of nucleic acids, phospholipids and phosphorproteins, it is essential in keeping up the acid-base balance in ruminants and activation of fermentation in the rumen (7, 8). The diet deficient in P leads to a decreased weight gain and milk production, disorexia, reproductive disorders and weak underdeveloped newborns.

Excess of P leads to Mg deficit observed at high concentrate feeding and ketosis (6). About 60-70 % of total Mg in the skeleton, of which one third is bound to phosphates and two third are absorbed on bone crystals. In soft tissue Mg serves for normalization of neuromuscular stimulation and enzyme activation. Mg ions activate phosphatase, peptidase, etc. (7). In case of Mg deficit the degenerative and necrotic changes are observed in kidneys, also Ca content in blood vessel walls, heart and skeletal muscles increases and violation of hormonal secretion occur (9). Mg deficit is mainly caused by imbalanced diet, starvation, an increased amount of P-containing food, intensive Mg excretion due to increased physical activity or endocrine dysfunction (8).

Se is important for reproductive function, and its level in liver depends on vitamin E content. At Se deficit in cattle there are delivery complications, detention of the afterbirth and endometritis.

Deficit of I results in increased infertility in cows, aborts, weak libido in bulls, and low semen quality. I is mainly know to be essential for thyroid function and its hormonal activity. In case of its deficit the interaction between pituitary and ovaries become weak and follicular cysts occur.

Zn multiply affects different processes as it is the basic microelement for animal growth and development, productive and reproductive functions, osteogenesis and hemopoesis. Presence of Zn in anterior pituitary is probably related to its role in production of gonadotropins which control sexual function. At Zn deficit the organic disorders develop in semeniferous tubules and spermatogenesis disturbance occurs. A disordered secretion of gonadotropins leads to deficit in testosterone and probably causes atrophy of testes. Excess of Zn may result in anemia, growth depression and toxemia.

Several thousands metalloproteins are shown to be involved in animal metabolism. For Zn there are more then 200 protein-containing compounds, including 160 metalloenzymes. Particularly, Zn citrate is an essential component secreted by prostate which improves motility of the spermatozoids in ejaculate. Besides, Zn is a powerful antioxidant agent able to stabilize cell membranes, and also it has the immunomodulating effect on T cells (10).

Zn stimulates reproductive function directly or via pituitary-gonadotropins. The insular function of pancreas is shown to be related to Zn content. Zn bound to insulin and glucagon is involved in metabolism of carbohydrates (11). Importantly, an increase Ca input causes an increased Zn requirement in animals.

Fe is essential for hemopoesis and intercellular metabolism. It is contained in blood hemoglobin, cytochromes and enzymes involved into oxidative and reductive processes. About 55-60 % of Fe in the body is hemoglobin-bound, about 24 % is hemoproteins-bound and involved into myoglobin formation, and 21 % is deposited in liver and spleen. Fe is important for enzymatic activity, immune functions and cholesterol metabolism. Both deficit and excess of Fe negatively affects animal health. At Fe deficit anemia occurs because of deficit in hemoglobin synthesis. An increased Fe content could result from long-term administration of Fe-containing preparations. Animals obtain Fe from feed and about 1 mg Fe is daily excreted with urine and faeces. Fe excess leads to gastrointestinal dysfunction, weight loss, kidney failure, liver diseases, arthritis, depression of cell and humoral immune responses, and increased risk of infections. Excess of Fe as an oxidative agent can generate free radicals able to destroy tissues and negatively affect spermatogenesis. An increased level of Fe in feeds and water depresses utilization of fodder protein and animal productivity. For better Fe and Ca assimilation they should be administrated separately, due to that the Fe bioavalibility increases 2-fold while the side effects of its preparations decreases $^1/_3$ times (12).

At chronic Fe excess a bloodletting and hepatoprotectors must be used. Zn and Ca preparations provide Fe assimilation, while phosphates prevent it. Vitamin E and high Zn doses decrease Fe assimilation and vitamin A deficit represses it. Vitamins C and B_{12} in combination with Cu contribute to Fe assimilation. Low acidity of gastric juice leads to low Fe assimilation, and Fe excess prevents Cu and Zn assimilation (13).

Deficit of essential microelements mostly leads to a decreased meat, wool and milk production, disturbed digestion and metabolism, repressed reproduction and weak newborns (14). Deficit of a single and especially several microelements causes endocrine disturbances and can decrease hormonal biosynthesis and activity thus negatively influencing reproduction (15).

Undoubtedly, biochemical monitoring of metabolic parameters in high-producing animals is actual, particularly in bull series of modern breeding, derived from mother cows with annual 15000-20000 kg milk production or daily 1500 g weight gain for milk and meat breeds, respectively.

Herein we summarize original data on the levels of the essential macroelements, in particular Ca, P, Mg, Fe and chlorides, and microelements, the Cu, Zn, Se and Mn, in blood serum of the superior sires as influenced by their age, beef or milk specialization and RED-factor expression.

Technique. In our experiment the 2-7 year meat Aberdeen Angus, Herefordm, Lymousine cattle, milk Red-and-White Holsteine, Black-and-White Holsteine, Ayrshire cattle, and also universal Brown Swiss cattle were assessed (*n* = 49). The surveys were carried out from 2011 to 2013 in Head Center for

Farm Animal Reproduction (Moscow Province). Feeding, housing and sampling were in accordance with National technology for freezing and using semen of bull series (16). Blood for analysis was traditionally sampled immediately after semen sampling before feeding according to planned veterinary and sanitation measures (16).

Ca, P, Mg, Fe macroelements and chlorides were tested in blood serum on a ChemWell 2902 analyzer (AwareneessTehnology, USA), Cu, Zn, Se, Mn microelements were analyzed in blood using an atomic absorption spectrometer Kvant-2A (Russia).

The investigated parameters were an ejaculate volume, the spermatozoid number per 1 ml, the percentage of spermatozoid motility in the native, diluted, frozen and thawed semen and in the samples frozen, thawed and then incubated at 38 °C for 5 hours. A total spermatozoid number per ejaculate, semen dose number per each sire, frozen semen dose number sampled during 24 hours, and the percentage of culled native ejaculates were also assessed.

All technological steps corresponded to National technology for freezing and using semen of bull series (16).

MS Excel was used for data statistical processing.

Results. We studied micro and macroelement levels in blood of bull series as influenced by age, type of productivity, RED-factor and parameters of sperm production.

Among the years of observation (Table 1) the electrolytic exchange (Ca, P, Mg, Fe) and Cu, Zn, Se, Mg microelements level in blood serum in all bull series were within physiological limits while in Fe, Se contents and Ca:P rate there were some discrepancies, particularly Ca:P = 1.54 compared to physiological norm ranged from 1.70-2.00, so 10-30 % decrease observed).

1. Content of macro- and microelements in blood serum of bull sires (n = 49, $X \pm x$, Head Center for Farm Animal Reproduction, Plc., Moscow Province)

Parameter	2011, spring	min-max	2012, spring	min-max
Ca, mmol/l	2.61±0.14	2.22-2.82	2.45±0.25	2.10-3.36
P, mmol/l	2.64±0.34	2.01-3.89	2.11±0.40	1.72-3.72
Mg, mmol/l	0.94±0.13	0.70-1.49	0.88±0.09	0.69-1.15
Fe, mmol/l	31.46±9.25	18.83-59.45	31.14±5.33	20.62-43.77
Se, μmol/l	2.04±0.41	1.29-3.41	1.13±0.25	0.53-1.63
Cu, μmol/l	14.39±2.04	11.76-21.44	16.00±2.11	13.02-23.48
Zn, μmol/l	33.00±6.72	22.21-52.37	40.16±7.24	24.65-55.67
Ca: P	–	–	1.54±0.25	0.85-1.92
Chlorides, mmol/l	103.64±4.66	87.58-110.87	105.54±4.09	97.5-113.82

Comments. Dashes means no parameters detected.

In 2011 Ca level in 46 bulls (94.00 %) was close to upper limit ranging from 2.22 to 2.82 mmol/l compared to physiologically normal values from 2.22 to 3.33 mmol/l. Nevertheless, next year the parameter became worse and ranged from 2.10 to 3.36 mmol/l including normal values in 30 bulls and decreased values in 36.70 % bulls. We suggest this fact being caused by more intensive exploitation and predominance of concentrate feed that was clearly indicated by P value in blood serum (see Table 1).

In 2011 P content in blood serum, because of concentrate feeding, in all bulls (100 %) exceeded the norm ranging from 2.10 to 2.50 mmol/l in 36.73 % bulls, from 2.51 to 3.00 in 51.00 % bulls and from 3.01 mmol/l in 12.46 % bulls. Therefore, the parameter was exceeded in 18 animals by 19.0-60.0 %, in 25 animals by 42.80-100 %, and in 6 animals more then 2 times. In 2012 after the diet was changed according to concentrate ratio the P level improved in 32 animals (65.00 %), but in 16 bulls (32.00 %) the parameter remained exceeded.

The Mg concentration in blood serum in both years was below norm in 9 bulls, and in 2012 a general trend to minimization was observed in all animals.

Because of high local Fe content in fodder and water, it is constantly above the norm in the bulls from Head Center for Farm Animal Reproduction, Plc., particularly in 2011 and 2012 51.00 % and 67.00 % animals possessed an excess of Fe in blood serum. An excess of phosphates is known to inhibit Fe absorption (13). According to our data (see Table 1), P content was inversely proportional to Fe content. In 2011 the parameter value was the same as or more then normal in 18 and 25 bulls, respectively, and next year in 32 animals the P content was stabilized but Fe content increased (see Table 1).

Selenium, being toxic when exceeded in level, could be additionally obtained only from feed premixes. In 2011 in 85.70 % bulls its concentration in blood serum was above the norm, particularly 1.52-2.00 μmol/l in 17 sires (35.00 %), 2.00-2.50 μmol/l in 22 sires (45.00 %) and above 3.00 μmol/l in 3 sires (6.00 %). Next year the indexes decreased significantly, ranging from 1.54 to 1.63 μmol/l in 10.00 % bulls.

A physiological antagonism exists between Cu and Mn, Zn, Ca, Cd. Fe also can depress Cu assimilation (13). In our experiment the blood Cu concentration exceeded the norm in 4 bulls in 2011 and in 11 bulls in 2012.

Zn deficit in animals is mainly manifested in weight loss with specific clinical symptoms (17). During investigation in 2011 the index ranged form 22.20 to 38.50 μmol/l in 41 bulls (84.00 %) being Zn deficient, but next year increased about 2 times due to special diet, nevertheless, 21 bull remained Zn deficient.

Chlorides in both years were in fact the same (see Table 1), being increased in level in 2011 in 9 bulls and in 2012 in 12 bulls with the indexes from 108.72 to 110.87 mmol/l and from 108.84 to 113.72 mmol/l, respectively.

Thus in bull sires blood serum concentration of macro and microelements depends mainly on fodder amount and quality, so the animal diet must be corrected based on blood biochemical monitoring.

To estimate the intensity of macro and microorganism metabolism as influenced by a productive type, the data were compared with respect to milk, meat or universal types of the breeds (Table 2).

2. Content of macro- and microelements in blood serum of bull sires depending on a type of breed productivity (n = 49, $X \pm x$, Head Center for Farm Animal Reproduction, Plc., Moscow Province, 2011-2012)

Parameter	Type		
	meat, n = 10	milk, n = 36	universal, n = 3
Ca, mmol/l	2.38±0.18	2.49±0.26	2.32±0.25
P, mmol/l	2.00±0.29	2.15±0.42	1.99±0.60
Mg, mmol/l	0.87±0.08	0.88±0.10	0.91±0.05
Ca: P	1.55±0.23	1.53±0.25	1.59±0.46
Fe, mmol/l	30.28±6.31	31.41±5.23	31.10±4.08
Chlorides, mmol/l	105.37±3.85	105.32±4.14	108.23±4.97
Se, μmol/l	1.27±0.25	1.10±0.24	0.96±0.14
Cu, μmol/l	15.77±1.62	15.85±2.20	18.49±0.45
Zn, μmol/l	41.72±6.21	40.64±7.02	30.64±6.24

No reliable differences in blood serum macro and microelement levels were shown between the types at the same housing and feeding. Despite the Ca to P balance in the diet and admissible levels in animal blood the Ca: P ratio fluctuated among the groups from 1.16 to 1.19, being below norm of 1.70-2.00. Therefore, at excess of concentrates the bulls were deficient on motion. In universal breed the Zn and Ca levels were 20 and 3-30 % below the norm, respectively.

In all groups the Fe level of 28.64 mmol/l was 10 % above the physiological maximum. As far as Fe excess is obtained from plant fodder and water the premixes should be corrected based on blood chemistry and antagonism of elements, particularly Fe and Ca, Fe and Zn, Mn and Fe, Cu and Zn, etc.

Animal coloration is commonly known to result in different response to insolation, that in turn affects vitamin D production and finally may impact on hormonal activity, definite exchange processes and metabolism in general (18). We studied the impact of RED factor on blood macro and microelements in Holsteine bull sires homozygous on coloration (Table 3).

3. Content of macro- and microelements in blood serum of RED factor homozygous bull sires depending on sensitiveness to insolation (n = 33, $X \pm x$, Head Center for Farm Animal Reproduction, Plc., Moscow Province)

Parameters	Holsteine bulls		Difference, %
	Red-and-White (n = 13)	Black-and-White (n = 21)	
Ca, mmol/l	2.56±0.37	2.46±0.17	–3.9
P, mmol/l	2.29±0.50	2.08±0.35	–10.2
Mg, mmol/l	0.91±0.09	0.86±0.09	–5.5
Fe, mmol/l	32.13±5.09	31.39±5.44	–2.3
Se, μmol/l	1.14±0.23	1.03±0.21	–9.6
Cu, μmol/l	15.48±1.67	16.13±2.56	+4.2
Zn, μmol/l	41.11±5.45	40.56±8.07	–1.4
Ca: P	1.49±0.30	1.53±0.21	+2.7
Chlorides, mmol/l	105.00±3.17	105.68±4.83	+0.4

No reliable relationships were found between the mineral exchange and honozygosity on RED factor affecting sensitivity to insolation, however in Black-and-White bulls compared to Red-and-White bulls the average values of the main indexes were somewhat lower.

4. Content of macro- and microelements in blood serum of bull sires depending on age (n = 49, $X \pm x$, Head Center for Farm Animal Reproduction, Plc., Moscow Province)

Parameters	Age, months	
	< 30 (n = 28)	≥ 30 (n = 21)
Ca, mmol/l	2.48±0.24	2.41±0.26
P, mmol/l	2.12±0.35	2.09±0.46
Mg, mmol/l л	0.88±0.09	0.88±0.10
Fe, mmol/l	32.57±5.64	29.24±4.41
Se, мкмμmol/l	1.10±0.23	1.16±0.29
Cu, μmol/l	15.87±2.20	16.26±2.03
Zn, μmol/l	38.60±6.70	42.65±7.39
Ca: P	1.54±0.28	1.53±0.24
Chlorides, mmol/l	105.61±4.39	105.51±3.78

The age of bull also had no reliable effect on the parameters studied (Table 4). Noteworthy, in young bulls up to 30 months of age an average Zn and Fe levels were 10 % below and above those in adults, respectively. This fact is worth special attention as even the Zn level enough for growth is insufficient for spermatogenesis, and Zn deficit during growth leads to infertility and skeleton abnormalities such as dwarfism or elongation of tubular bone characteristic to infantile development.

In order to evaluate the influence of main macro and microelements on sperm production, the bulls were conditionally divided into groups with deficient, normal or excess concentrations of some studied elements (Tables 5, 6). Grouping animals exclusively deficient or excessive on a single element was impossible as a deficit in any one element is usually compensated by an excess of the other, so the definite conclusions can be hardly made.

The high quality ejaculates were 10 % more in number among bulls with a stable Ca:P rate, i.e. in the animals with no hidden ketosis. Sperm content and number of frozen semen doses per bull were a little bit higher among the animals with Ca:P of 1.01-1.59 due to excessive protein diet. Nevertheless, their sperm was more sensitive to freezing and, thus, less viable. The percentage of rejected ejaculates in bulls with violation of Ca:P was 6.74 % higher compared to that in animals without Ca:P abnormalities. Besides, Ca:P normalization contributed to 9.1 % more viability of sperm during incubation at 38 °C for 5 hours. Best sperm quality was observed in bulls with normal Cu level as the number of rejected ejaculates was 10 % lower, while the semen content and dose number were 6 % and 19 % higher, respectively, compared to bull excessive on Cu. Zn affected on the ejaculate volume, being a component of prostate secretion. In bulls with normal Zn level the ejaculate volumes were 4.3±0.9 ml compared to 3.9±0.9 ml in bulls with a decreased Zn level ($P < 0.05$). In our investigation the bulls were found out to be mostly deficient on Zn, while in the normal group the index was close to the lower limit value, and in the same group there were the animals excessive on Cu and Fe. At that the rejected semen number was 15 % higher then in clearly Zn deficient animals. Spermatozoid motility after thawing and incubation at 38 °C for 5 hours was higher then in animals with normal Zn level in blood serum. An excess of chlorides in blood had a negative impact on semen quality and viability due to influenced electrolytic balance in generative cells.

5. Quantitative parameters of sperm production as related to the level of macro and microelements in blood serum of bull sires (n = 49, $X±x$, Head Center for Farm Animal Reproduction, Plc., Moscow Province)

Parameters	n	Number of ejaculates per bull	Ejaculate volume, ml	Spermatozoids in an ejaculate: content, $\times 10^9$/ml	Spermatozoids in an ejaculate: total, $\times 10^9$
Ca: P					
Below normal level (1.01-1.59)	26	11.4±2.0	4.3±1.0	1.28±0.27	5.4±1.4
Normal level (1.70-2.00)	12	10.8±2.7	4.2±0.9	1.23±0.22	5.0±0.5
Zn					
Below normal level	12	11.8±1.4	3.9±0.9	1.34±0.24	5.2±0.9
Normal level	36	11.0±2.2	4.3±0.9	1.26±0.25	5.3±1.4
Chlorides					
Normal level	38	11.4±2.0	4.1±0.9	1.30±0.30	5.2±1.3
Above normal level	10	11.0±2.9	4.5±1.1*	1.20±0.20*	5.1±1.3
Cu					
Normal level	33	11.2±2.3	4.1±1.0	1.26±0.24	5.1±1.1
Above normal level	11	11.5±2.0	4.3±0.7	1.33±0.30	5.5±1.3

* $P < 0.05$.

6. Qualitative parameters of sperm production as related to the level of macro and microelements in blood serum of bull sires (n = 49, $X±x$, Head Center for Farm Animal Reproduction, Plc., Moscow Province)

Parameters	n	Number of ejaculates per bull	Rejected ejaculates: total	Rejected ejaculates: %	Frozen doses per bull	Spermatozoid motility, %
Ca: P						
Below normal level (1.01-1.59)	26	11.4±2.0	3.7±2.8	32.32	1293	9.2±3.6
Normal level (1.70-2.00)	12	10.8±2.7	2.3±2.1	25.58	1238	10.1±5.7
Zn						
Below normal level	12	11.8±1.4	2.5±2.3	21.28	1514	8.6±4.4
Normal level	36	11.0±2.2	4.0±2.6	36.73	1127	10.6±4.0
Chlorides						
Normal level	38	11.4±2.0	3.7±2.8	33.64	1209	10.9±5.3
Above normal level	10	11.0±2.9	3.8±3.2	33.64	1259	8.6±2.9
Cu						
Normal level	33	11.2±2.3	3.3±2.5	29.81	1196	11.2±5.3
Above normal level	11	11.5±2.0	4.6±3.7	39.68	1473	7.6±1.5

Comments. Spermatozoid motility was assessed after incubation at 38 °C for 5 hours.

Obtained data indicate the necessity of complex study of macro and microelements interaction. Deficient element should be compensated by premixes and additives considering local biogeochemical conditions (19).

The higher productivity and weight gain, the more intensive metabolism occurs and more macro and microelements are required (1). Consequently, their optimal values in cattle blood serum should be revised according to breed specialization, animal sex, age, physiological state, seasons, rearing technology and exploitation.

Thus, in bull sires the blood level of macro and microelements depends on balanced diet, mode of exploitation, age, breed specialization, and unreliably on RED-factor. In case the levels of elements change towards deficit or excess, the spermatogenesis is disturbed both qualitatively and quantitatively.

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