

THYMUS DEVELOPMENT IN CALVES KEPT UNDER NORMAL FEDING REGIMEN

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Summary

The calf immune system is very vulnerable to the hypofunction of thymus. In calves the thymus appears to increase in weight and size up to eight weeks of age. At one week of age the thymus weight from 100 to 200 g; after four to six weeks of age from 400 to 600 g. Involution of the thymus begins in the cervical region.

According to our observations, significantly lower the thymus weight of calves was found in Pisek, compared with Znojmo. On the other hand, calf thymus weights found after the significant diminishment of K and P-fertilizaion - in 1996, are higher especially in the "relative" healthy calves, compared with 1991 year. With the respect to the above described results we can suppose that the Mg - deficit and simultaneously a possibility of a lower Zn content in forages, can have a detrimental effect on covs and on immune status of newborn calves, in the potato region especially. The finding about the thymus weight it seems to be important not only about the animal immunity but generally concerning the ecology. However, very little is known about Zn content (in forage crops in the Pisek and Znojmo districts, which probably is an important factor, respnsibel for the calf thymus weight. Various of the above-mentioned experiments and observations indicate the possibility that problems with the thymus hypofunction - calf immunity (neonatal diarrhea, especially) are primarily associated with Mg-Zn deficiency in dry cows - calves. More research is needed about trace elements and Mg utilization in ruminants and how it influence the immune response in cattle. The cooperative grant could be useful between our and an other country research institute.

Introduction

It is clear from literature sources that the calf immune system is very vulnerable to the hypofunction of thymus. In calves the thymus appears to increase in weight and size up to eight weeks of age. At one week of age the thymus weight from 100 to 200 gm; after four to six weeks of age from 400 to 600 gm. Involution of the thymus begins in the cervical region (Getty, 1975).

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It has long been recognized that the thymus gland of mammals atrophies at about the time of adolescence. This lymphoid organ is sensitive to the action of adrenal glucocorticoids, embryological basis is the same thyroid gland. Various experiments have demonstrated that the thymus is essential for normal development and maintenance of immunological competence. It has been proposed that normally, a thymic hormone reacts with the lymphoid cells from the thymus and other lymphoid tissues to produce cells that are capable of reacting with antigens (Swenson, 1984).

The thymus is the central lymphoid organ for differentiation and maturation of T cells. Lymphoid systems of sheep and cattle contain a large number of $\gamma\delta$ T cells, in striking contrast to the lymphoid systems of human and mice. In neonatal animals particularly, these cells comprise the predominant fraction of T cells in the blood. The number of both $\alpha\beta$ and $\gamma\delta$ T cells increases during late gestation. During the first 1-2 weeks after birth, the number of $\gamma\delta$ T cells decreases slightly, whereas the number of $\alpha\beta$ T cells expands rapidly and accounts for 60% of the T-cell pool at this time (Hein et al., 1990).

In district Pisek it has been known about from seventies that the thymus weight is smaller compared with the sixties, after the significant elevation of the NPK fertilization. Therefore, it was intended to establish the (a) status of calf thymus weight after changes of NPK fertilization, (b) association between calf thymus weight, compared potato and beet-growing regions, according to the age of calves.

Materials and methods

In the slaughterhouse, in Pisek 73 and 78 less than five-month old calves (1991 and 1996 years) were slaughtered and necropsy performed by veterinarians. Calves represented animals from normal agricultural production systems kept under normal feeding and housing management on farms. Mostly, all the calves were under veterinary supervision through routine daily visits to each farm and were judged to be ill (or without the pathological findings) on the basis of medical history and physical examination. The diagnosis was based upon the presence of some symptoms with chronic loss of appetite most prevalent. The data of the thymus weight were collected during the period of January-February, 1991 and 1996. Especially, it was intended to establish the association between the thymus weights in 1991 and 1996 years, after significant reduction of NPK fertilization during last five years in district Pisek (potato-growing region).

Results and discussion

Calves and calf thymus observations presented in Table 1 and Table 2 are common findings in calves slaughtered in the Pisek district and this situation there has been known from seventies. In general, it was found (Hlásný, 1992)

that thymus development in calves can be about 10 times smaller (Table 1 and Table 2) compared with the literature sources. On the basis of cooperation with some others (Veterinary district in Czech Republic), during 1994 year, the same or higher weights were obtained (informative data only):

Region	District	Calves age	Thymus weight, mean (g)
Prague	Benešov ¹	4 weeks	35
Pilsen	Klatovy ¹	1 to 4 w	140
		6 weeks	170
Budweise	Pelhrimov ^{1,2}	5 to 8 w	240
		8 to 12 w	310
Brno	Znojmo ²	4 weeks	230
		5 weeks	190
		6 to 10 w	330

¹ Potato-growing regions

² Beet-growing regions

In Znojmo district the thymus weights seems to be larger, and there was a very low incidence of neonatal calf diarrhea, compared to potato-growing regions. The most commonly recognized causes of neonatal calf diarrhea are rota-coronavirus, cryptosporidia, enterotoxigenic *E. coli* (Smith, 1990). Regarding age of the calf, the highest risk of mortality occurred during the first 3 weeks, the peak age for diarrhea occurred in the first 2 weeks, and the median age of diarrhea occurrence was 8 days (Perez et al., 1990). In district Pisek, using a mineral supplement containing 80% more of Mg in 7300 highly-pregnant heifers and first calves in the 1988 winter season, it was found that mortality of newborn calves decreased by 2.9% (decrease of total losses from 0,9% to 8,0%) - compared with the same 1987 year period when a mineral mixture with lower Mg content had been used (Hlásný, 1989).

According to these results and the literature sources it can be suggested that Mg-deficiency plays also an important role in animal immunodeficiency. Classen and Lecture (1989) found, that Mg deficiency increases the action of a stress. On the other hand the Mg supply diminished the atrophies of thymus and lymphonodes. In addition, the calf thymus is a reservoir of magnesium (Delbet, 1929). The lower level of immunoglobulins certainly reflects decreases synthesis per immunocopotent cells and antibodies, like other proteins, are synthesized more slowly in Mg-deficiency (Grace and O'Dell, 1970; Lizarralde, et al., 1974; Menaker and Kleiner, 1952; Schwartz et al., 1970). This decrease in antibody-producing cells might be connected with the fact that lymphoblastic transformation, a prerequisite of the secretion of antibodies by lymphoblasts, is more difficult in vitro with lymphocytes from Mg-deficient rats (Mease, 1974).

It has been observed that application of N-fertilizer, which may increase K uptake by plants and/or decrease Mg utilization by livestock, often is

associated with the occurrence of hypomagnesiemia (Fontenot et al., 1973). A high K/(Ca+Mg) ratio in forages is responsive for the subclinical and/or clinical hypomagnesiemia in cattle (Kemp et Hart, 1957).

In district Pisek, there was applied (1985-1990 and 1990-1995) the following average annual rate of commercial fertilizers (kg/ha of farm land):

	Nitrogen	P ₂ O ₅	K ₂ O
1985-1990	105	75	80
1990-1995	80	20	15

Under these normal conditions of the NPK fertilization, analysis of 750 samples of 30 roughages (Hlásný, 1989) showed that obtained findings, significantly differs from the results published in Czech Republic in sixties: e.g. the clover - grass dry matter contained 56% more of K and 36% less of Mg and 33% less of Ca (Hlásný, 1989). By computer evaluation of 1280 samples preserved roughages it was found that they contained 2,2% K; 0,52% Ca; 0,19% Mg; 0,28% P and 0,031% Na (Hlásný, 1989). These results show a tendency of the K/(Ca + Mg) values increase and then a tendency to Mg - deficiency. This tendency was higher in potato-growing region (Hlásný et Vesely, 1990), where the value of this quotient is significantly higher (Pisek region), compared with the beet-growing region (Znojmo).

The effect of Zn deficiency on immunity is of particular interest. Shanklin et al. (1968) repeatedly observed that the thymus was the most markedly atrophied organ in Zn deficient pigs and Quarteman (1974) reported the same observation in zinc deficient rats. Also Fraker et al. (1977) concluded that zinc deficiency caused rapid atrophy of the thymus and interfered with T-cell helper function in the young adult mouse but had little effect on the B-cells for the time periods studied.

Increasing levels of inorganic P in soils or solution culture can, by many mechanisms, depress Zn concentration in leaves and induce a true deficiency such that symptoms of Zn deficiency appear (Olsen, 1972). The resulting disorders are usually called "P-induced Zn deficiencies", and can sometimes be alleviated by Zn fertilization. Loneragan et al. (1982) suggested that low Zn combined with high P in solution may enhance accumulation of P in old leaves to concentrations which are toxic, thereby inducing symptoms of P toxicity which have been mistakenly identified as symptoms of Zn-deficiency. Results with subterranean clover (Loneragan et al., 1979), corn and potato (Christensen et Jackson, 1981) support the hypothesis that Zn deficiency caused to accumulate to toxic levels in old leaves. Saeed (1977) found that P-fertilizers decreased the ability of calcareous soils to retain zinc.

New assessments seem to indicate that for safe and adequate provision 45 to 50 mg of Zn/kg DM of diet should be present, if all interfering factors are taken into account. Such a content, is practically not always present in the feed rations, in dry cows especially, Compare the Czech (Zeman, 1991) and the

U.S.A. (Ensminger et al., 1990) conditions, the worse situation seems to be concerning the Zn-content in forages in Czech Republic (at the similar level of crude protein): alfalfa- 23 and 36 ppm: Corn- 27 and 70ppm, respectively.

Conclusions

According to our observations, significantly lower the thymus weight of calves was found in Pisek, compared with Znojmo. On the other hand, calf thymus weights found after the significant diminishment of K and P-fertilizaion - in 1996, are higher especially in the "relative" healthy calves, compared with 1991 year. With the respect to the above described results we can suppose that the Mg - deficit and simultaneously a possibility of a lower Zn content in forages, can have a detrimental effect on cows and on immune status of newborn calves, in the potato region especially. The finding about the thymus weight it seems to be important not only about the animal immunity but generally concerning the ecology. However, very little is known about Zn content (in forage crops in the Pisek and Znojmo districts, which probably is an important factor, responsibel for the calf thymus weight. Various of the above-mentioned experiments and observations indicate the possibility that problems with the thymus hypofunction - calf immunity (neonatal diarrhea, especially) are primarily associated with Mg-Zn deficiency in dry cows - calves. More research is needed about trace elements and Mg utilization in ruminants and how it influence the immune response in cattle. The cooperative grant could be useful between our and an other country research institute.

Table 1. - THE SITUATION ABOUT THE PATHO-ANATOMICAL DIAGNOSIS AFTER KILLING OF CALVES (PISEK DISTRICT)

Diagnosis	Group of calves according to age			
	1-4 weeks	1-3 months	3-5 months	
Arthritis-enteritis:	1991	33%	14%	12%
	1996	-	-	-
Enteritis:	1991	27%	25%	16%
	1996	20%	2%	-
Bronchopneumonia:	1991	7%	32%	24%
	1996	20%	22%	-
Fracturae extremitatis:	1991	-	11%	-
	1996	10%	-	-
Without the path. findings:	1991	33%	18%	48%
	1996	50%	76%	100%

Table 2. - THE FINDINGS ABOUT THE THYMUS WEIGHT ACCORDING TO THE CALVES MEAT CLASSIFICATION AFTER KILLING (PISEK DISTRICT)

Group of calves	Calves meat classification (+)		Total	
	1	2		
I. 1 to 4 weeks aged				
Calves number:	1991	5	9	14
	1996	5	5	10
Thymus weight, mean (g)	1991	35	22	
	1996	79	14	
Min. and max. weight (g)	1991	30-50	10-35	10-50
	1996	40-200	5-25	5-200
II. 1-3 months aged				
Calves number:	1991	4	22	26
	1996	39	12	51
Thymus weight, mean (g)	1991	79	31	
	1996	125	34	
Min. and max. weight (g)	1991	50-120	5-90	5-120
	1996	40-310	10-140	10-310
III. 3-5 months aged				
Calves number:	1991	14	19	33
	1996	17	-	17
Thymus weight, mean (g)	1991	59	26	
	1996	106	-	
Min. and max. weight (g)	1991	35-110	0-75	0-110
	1996	15-360	-	15-360

(+) 1/ Meat valuable and 2/less valuable for human nutrition

RAZVOJ TIMUSA U TELADI U NORMALNOM NAČINU HRANJENJA

Sažetak

Imuni sistem teladi vrlo je osjetljiv na hipofunkciju timusa teladi. Čini se da se timus povećava težinom i veličinom do osmog tjedna starosti. U tjedan dana starosti timus teži od 100 do 200 g; nakon četiri do šest tjedna starosti od 400 do 600 g. Invokucija timusa počinje u području cerviksa.

U opisanim rezultatima možemo pretpostaviti da pomanjkanje Mg i istovremeno mogućnost nižeg sadržaja Zn u krmu može djelovati na krave kao i na imuno stanje novorođene teladi, osobito u području proizvodnje krumpira. Nalaz o težini timusa izgleda važan ne samo zbog imuniteta životinje nego općenito u vezi s ekologijom. Vrlo malo se zna, međutim, o sadržaju Zn u krmnim usjevima u područjima Pisek i Znojno, što je vjerojatno važan čimbenik, odgovoran na težinu timusa teladi. Spomenuti pokusi i opažanja upućuju na mogućnost da su problemi hipofunkcije timusa - imunitet teleta (osobito neonatalni proljev) prvenstveno u vezi s pomanjkanjem Mg-Zn. Potrebno je više istraživanja o elementima u tragovima i iskorištavanju Mg u preživača i kako ono utječe na imunu reakciju u goveda.

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