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Regional Hypomagnesaemia and Parturient Hypocalcaemia of Milking Cows – Associations with Mg/Ca Ratio of Cropland

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Abbreviations: HCa: Parturient Hypocalcaemia; HMg: Hypo-Mg;Hypomagnaesemia; [(Mg/Ca).soil] – Mg/Ca ratio in Finnish croplands in 1986-90; µ.HCa: Monthly Cases of HCa/100,000; µ.HMg: Monthly Cases of HMg/100,000; N: Northcombination of Vaas; Oulu and Lapland provinces; RC: Rural Centers; S: South, combination of other than North provinces; WhC: Whole Country

ABSTRACT

Hypomagnesaemia (HMg) of ruminats is a metabolic disease associated with relative or absolute dietary Mg-defic¬iency and climatic factors with rapid onset and remarkable lethality. Parturient Hypocalcaemia (HCa) occurs usually within 72 hours after parturition. Cropland Mg/Ca ratio has explained timothy Mg/Ca variation by 71 % (p = 0.001). Finnish (Mg/Ca).soil has been highest in North Finland during 1966-90, but regional difference decreased thereafter. This study is assessing associations between HMg and HCa of Finnish milking cows in 1979-96 with (Mg/Ca).soil from 1986-90 [(Mg/Ca).soil]. Cow data includes provincial annual data from1994-1996 and only December data from years 1979, 1981, 1983, 1985, 1989, 1991, 1992 and 1993. Cow incidence data (1/100,000)/month is represented by figures and calculations. Because of some missing data from 1979-93, calculations are given mainly from period 1994-96, "(94-96)", including 8,361 HMg and 107,988 HCa cases. Number of provinces was 12. Results are given by North and South Finland, too.

Results: [(Mg/Ca).soil] explained about coincidental [HMg.(85-91)] negatively by 38 % (p = 0.032) and trend-like negatively [HMg.(94-96] (by 25 %, p = 0.100) and positively HCa (by 6.8 %, p = 0.413). HMg and HCa incidence were higher in South, but relative incidence of Åland (with high Ca/Mg ratio) to /Whole Country) was 0.73 by HCa.

Conclusion: Association of cropland Mg/Ca ratio with HMg and HCa was similar but much weaker than expected by the soil-timothy studies in the 1970's. As a background phenomenon soil Mg/Ca could affect slightly on Ca and Mg balance of animals and humans, negatively and positively. Comparing of HMg and HCa incidence especially in carbonate soils are suggested.

Introduction

Hypomagnesemia (HMg) of ruminats is a metabolic disease associated with absolute or relative dietary Mg-deficiency [1] and weather conditions [2] with rapid onset and remarkable lethality. The risk is increased when cows are grazing pasture, especially in Spring and Autumn when the absorption of magnesium is influenced by factors including: high levels of potassium, nitrogen and moisture content and low levels of sodium[1]. Weather conditions, e.g. cold weather associated with low sugar content of grass can be a decisive factor [2]. Parturient Hypocalcaemia (HCa) (in Finnish "poikimahalvaus"), with synonyms: Puerperal Tetany, Lactation Tetany, Milk fever, occurs usually within 72 hours after parturition, associated with the increased calcium demand and probably are the reflection of a temporary failure of calcium homeostatic mechanisms [3]. Cropland Mg/Ca has explained timothy Mg/Ca variation 71 % (p = 0.001) [4-6]. It has been highest in North Finland (North) and lowest in Åland[7]. This study

assesses provincial HMg and HCa changes during 11 periods and their associations with [(Mg/Ca).soil] from 1986-1990. Since 1983 veterinary surgeons have reported grass tetany ("laidunhalvaus") and other "hypomagnesemias" under label "hypomagnesemia".

Materials and Methods

Cropland magnesium and calcium values by Rural Centers (RC), mg/l, are from [8] and represented in [7] (Total"). Provincial Mg and Ca values are attained by dividing and combinig RC values as represented in [9]. They are represented as mEq/L in Table 1. Map and label numbers of Finnish Provinces are from [10], but they are put to the same order as respective RC's in [7,8]: (08 Kuopio, 07 North Karelia; last 03 Åland). In [7] Kuopio RC/province had high (Mg/Ca) ratio in 1966-70, but relatively lower in 1986-90 [9]. That's why Kuopio province was discarded and Vaasa province, (which includes even the biggest part of RC16, Central Ostrobothnia) [9,10] was accepted to North (group) with Oulu and Lapland. Uusimaa and Häme with higher (Mg/Ca) ratio than Vaasa were discarded from the North because North has some climatic factors in common and correlations are calculated by provinces. Because of scanty data (of HMg) whole country (WhC), South (S) and North (N) values were calculated by dividing their total incident cases by their total number of cows (Σ/Σ).

Table 1: Provincial cropland Mg and Ca contents and their ratios in Finland during 1986-90.

Provincial cropland Mg and Ca contents and their ratios in Finland during 1986-90															
	01 Uusimaa	02 Turku and Pori	04 Häme	05 Kymi	06 Mikkeli	08 Kuopio	07 North. Karelia	09 Central Finland	10 Vaasa	11 Oulu	12 Lapland	03 Åland	WhC	South	North
	mEq/L														
Mg	31.7	22.8	22.6	20.9	11.8	14.6	12.9	13.2	16.3	17.8	17.4	10.9	17.7	17.9	17.2
Ca	101.8	92.4	84.3	83.4	68.5	62.4	60.5	60.3	61.9	55.2	51.3	134.6	76.4	83.1	56.1
Mg/Ca	0.312	0.246	0.268	0.251	0.173	0.234	0.214	0.219	0.264	0.322	0.339	0.081	0.24	0.22	0.31
(Mg/Ca).S/ (Mg/Ca).N															0.71

Number of milk/dairy cows (cows) by provinces for December 1983 are attained from [11], for May 1995 by Rural Business Districts from [12]. By [12] provincial data were formed as in [9], with one exception: cow number for Åland was readily given. Data of December 1983 was adjusted to June 1983 by multiplying the provincial numbers by ratio of dairy cows in May 1983 (663.1) [13] and December 1983 (634.2) [11]. Total number of dairy cows for 1979 is from [13], for 1980-1996 from [14]. Cow number estimates for other than 1983 and 1995 are attained by linear interpolation by total numbers (Table 2). By weighting provincial values by cow number 1983 or 1995 South/East ratio of (Mg/Ca) increases to 0.82-0.83. This suggests on lower Mg/Ca ratio in food/fodder [6].Provincial data for Hypomagnesemia (Hypomagnesemia and "Laidunhalvaus" together) and Parturient hypocalcaemia (HCa), "Poikimahalvaus" are from monthly reports of veterinary surgeons to Ministry of Agriculture and Forestry [15], containing ca 15 labels of treatments for cows. This source includes data from Decembers 1979, 1981, 1983, 1985, 1989, 1991, 1992 and 1993 and annual data from 1994, 1995 and 1996(Table 3). HMg cells from 1979-1993 include 7 empty cells and value of 8 cells was only 1. Data on Parturient hypocalcaemia are from the same source [15] (Table 4).

Table 2: Estimated numbers of dairy cows in Finnish provinces 1979-1996.

Estimated numbers of dairy cows in Finnish provinces 1979-1996													
0	**01 Uusi-maa**	**02 Turku and Pori**	**04 Häme**	**05 Kymi**	**06 Mikkeli**	**08 Kuopio**	**07 North. Karelia**	**09 Central Finland**	**10 Vaasa**	**11 Oulu**	**12 Lapland**	**03 Åland**	**Tot**
79.appr	37.3	69.3	68.2	56.1	54.0	51.6	80.1	42.8	136.3	104.9	26.1	3.4	730.1
81.appr	35.8	66.5	65.5	53.9	51.8	49.5	76.9	41.0	130.8	100.7	25.1	3.2	700.8
1983.Jun.adj	33.9	62.9	62.0	51.0	49.0	46.9	72.8	38.8	123.8	95.3	23.7	3.0	663.1
85.ipol	28.7	44.7	65.5	42.5	39.2	71.9	42.5	35.0	141.5	87.8	24.6	3.8	627.7
89.ipol	23.1	36.1	52.9	34.3	31.6	58.1	34.3	28.2	114.2	70.9	19.8	3.0	506.6
91.ipol	20.3	31.7	46.5	30.2	27.8	51.1	30.2	24.8	100.5	62.4	17.4	2.7	445.6

92.ipol	19.5	30.5	44.7	29.0	26.7	49.1	29.0	23.8	96.6	59.9	16.8	2.6	428.2
93.ipol	19.5	30.4	44.5	28.9	26.6	48.9	28.9	23.7	96.1	59.7	16.7	2.6	426.4
94.ipol	19.0	29.7	43.5	28.2	26.0	47.8	28.2	23.2	94.0	58.3	16.3	2.5	416.7
1995.May	18.2	28.4	41.6	27.0	24.9	45.7	27.0	22.2	89.9	55.8	15.6	2.4	398.7
96.appr	17.9	27.9	40.9	26.6	24.5	45.0	26.6	21.8	88.4	54.9	15.3	2.4	392.2

Table 3: Incidence of Hypomagnesaemia in veterinary reports. Data on 1979-93 are from Decembers, 1994-1996 from 12 months, e.g. 94.(12) and annual means (e.g. µ.94).

Incidence of Hypomagnesaemia in veterinary reports. Data on 1979-93 are from Decembers, 1994-1996 from 12 months, e.g. 94.(12) and annual means (e.g. µ.94).												
	01 Uusimaa	**02 Turku and Pori**	**04 Häme**	**05 Kymi**	**06 Mikkeli**	**08 Kuopio**	**07 North. Karelia**	**09 Central Finland**	**10 Vaasa**	**11 Oulu**	**12 Lapland**	**03 Åland**
Dec.79	38	25	21	10	8	6	6	2	19	25	4	1
Dec.81	25	22	10	23	4	2	21	3	16	14	1	0
Dec.83	33	19	16	12	7	15	1	5	10	13	4	1
Dec.85	29	14	8	12	4	5	15	0	24	8	0	5
Dec.89	11	12	12	9	4	9	9	0	7	20	1	2
Dec.91	6	7	16	18	6	8	6	0	23	7	1	6
Dec.92	2	8	10	16	5	1	8	1	7	11	0	2
Dec.93	8	8	6	27	4	5	10	0	15	16	2	2
94.(12)	117	131	222	317	189	298	252	98	436	336	28	27
95.(12)	117	164	149	314	155	325	198	365	432	281	31	18
96.(12)	201	154	226	243	132	357	206	105	482	258	40	17
µ.94	10	11	19	26	16	25	21	8	36	28	2	2
µ.95	10	14	12	26	13	27	17	30	36	23	3	2
µ.96	17	13	19	20	11	30	17	9	40	22	3	1

Table 4: Incidence of Parturient hypocalcaemia (HCa) in veterinary reports [15].

Incidence of Parturient hypocalcaemia (HCa) in veterinary reports												
	01 Uusimaa	**02 Turku and Pori**	**04 Häme**	**05 Kymi**	**06 Mikkeli**	**08 Kuopio**	**07 North. Karelia**	**09 Central Finland**	**10 Vaasa**	**11 Oulu**	**12 Lapland**	**03 Åland**
79.Dec	351	444	456	303	253	448	295	161	608	520	136	18
81.Dec	253	400	324	337	236	305	219	173	529	397	81	23
83.Dec	348	413	421	278	170	446	200	142	533	446	112	16
85.Dec	291	367	335	290	204	373	213	203	654	367	47	12
89.Dec	221	303	372	210	211	353	221	106	418	446	130	11
91.Dec	219	284	337	177	222	306	223	115	466	311	59	13
92.Dec	173	224	213	173	156	255	144	120	367	267	63	15
93.Dec	184	214	339	230	219	411	159	167	415	363	90	12
94.(12)	1755	2687	3549	2393	2008	4088	2112	1586	5445	4861	929	102
95.(12)	1384	2206	2826	1791	1883	3711	1604	1317	4569	4434	778	146
96.(12)	1256	1849	2668	1465	1836	3559	1529	1365	4498	4111	697	111

Results

S/N ratio of HMg was always >1. In 1979-96 it was 1.74 and in 1994-96 (during 12 month data) it was 1.49 (Table 5). Monthly HMg number in 1994-96 was 2.5-fold to indoor cases in 1979-93 (Figure 1). (Pasture effect?) HMg and (Mg/Ca) values of Åland are exceptional (Figure 1). Means of indoor (December) HMg values (1979-93) correlated significantly positively with annual (1994-96) values + 0.68 ($p < 0.05$). (Mg/Ca).soil (1986-90) associated most strongly, negatively and significantly, with coincidental HMg. (85-91) ($r = -0.62$, $p < 0.05$)(Figures 2&3). December HCa values (1979-93) correlated significantly positively with annual (1994-96) values + 0.80 ($p < 0.01$) (Figure 4 and Table 8). Ratio of HCa. (79-93)/HCa.(94-96) was 1.0. (Mg/Ca).soil (1986-90) associated very weakly positively with HCa. Periodical S/N ratio of HCa was higher in Decembers 1979-93 (1.40), than during 12 month periods in 1994-1996 (1.18), (Table 6&7). (Protective summer effect?) HCa values of South and North seem to comply quite well, their association by Pearson correlation was +0.56 - (non-significant, p slightly > 0.05) (Figures5-7) and (Tables 9-11).

Table 5: Provincial incidence of monthly Hypo-Mg Cases/100,000. Calculated by data in Tables 2 and 3.

Provincial incidence of monthly Hypo-Mg Cases/100,000. Calculated by data in Tables 2 and 3.															
	01 Uusimaa	02 Turku and Pori	04 Häme	05 Kymi	06 Mikkeli	08 Kuopio	07 North. Karelia	09 Central Finland	10 Vaasa	11 Oulu	12 Lapland	03 Åland	South.(Σ/Σ)	North.(Σ/Σ)	HMg.(S/N)
Dec.79	101.9	36.1	30.8	17.8	14.8	11.6	7.5	4.7	13.9	23.8	15.3	29.8	25.3	18.0	1.41
Dec.81	69.8	33.1	15.3	42.7	7.7	4.0	27.3	7.3	12.2	13.9	4.0	0.0	24.8	12.1	2.05
Dec.83	97.4	30.2	25.8	23.5	14.3	32.0	1.4	12.9	8.1	13.6	16.9	32.8	25.9	11.1	2.33
Dec.85	101.2	31.3	12.2	28.2	10.2	6.9	35.3	0.0	17.0	9.1	0.0	132.3	24.6	12.6	1.95
Dec.89	47.6	33.3	22.7	26.2	12.6	15.5	26.2	0.0	6.1	28.2	5.0	65.6	22.5	13.7	1.65
Dec.91	29.5	22.1	34.4	59.6	21.6	15.7	19.9	0.0	22.9	11.2	5.7	223.7	27.5	17.2	1.60
Dec.92	10.2	26.2	22.4	55.2	18.7	2.0	27.6	4.2	7.2	18.4	0.0	77.6	20.8	10.4	2.00
Dec.93	41.1	26.3	13.5	93.5	15.0	10.2	34.6	0.0	15.6	26.8	12.0	77.9	27.6	19.1	1.44
µ.94	51.3	36.8	42.6	93.6	60.5	52.0	74.4	35.2	38.7	48.0	14.3	89.7	55.5	39.5	1.40
µ.95	53.6	48.1	29.8	96.9	51.9	59.3	61.1	137.0	40.0	42.0	16.6	62.5	63.4	38.4	1.65
µ.96	93.6	45.9	46.0	76.2	44.9	66.2	64.6	40.1	45.4	39.2	21.7	60.0	58.6	41.0	1.43
µ.(79-93)	62.3	29.8	22.1	43.4	14.4	12.3	22.5	3.6	12.9	18.1	7.4	80.0	24.9	14.3	1.74
µ.(79-96)	63.4	33.6	26.9	55.8	24.7	25.0	34.5	21.9	20.7	24.9	10.1	77.5	34.2	21.2	1.61
µ.(85-91)	59.4	28.9	23.1	38.0	14.8	12.7	27.1	0.0	15.3	16.2	3.6	140.5	24.9	14.5	1.73
µ.(94-96)	66.1	43.6	39.5	88.9	52.4	59.1	66.7	70.8	41.4	43.0	17.5	70.7	59.1	39.6	1.49

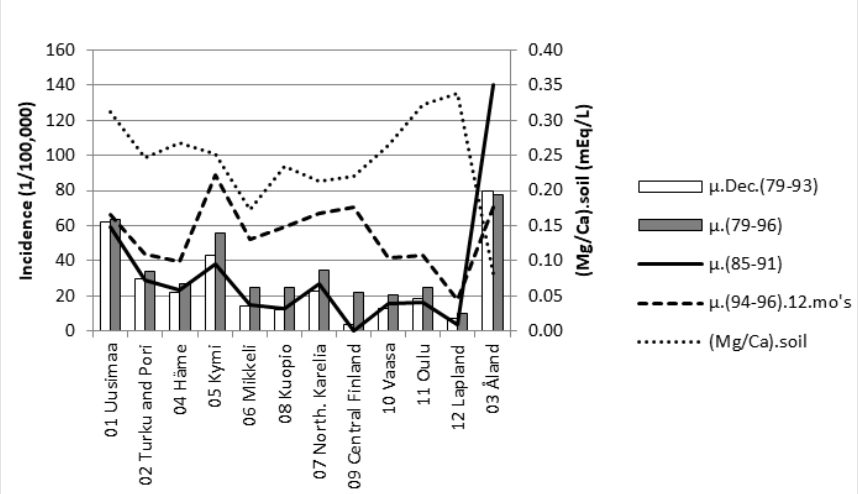

Figure 1: Hypomagnesaemia in four periods and (Mg/Ca)Soil.

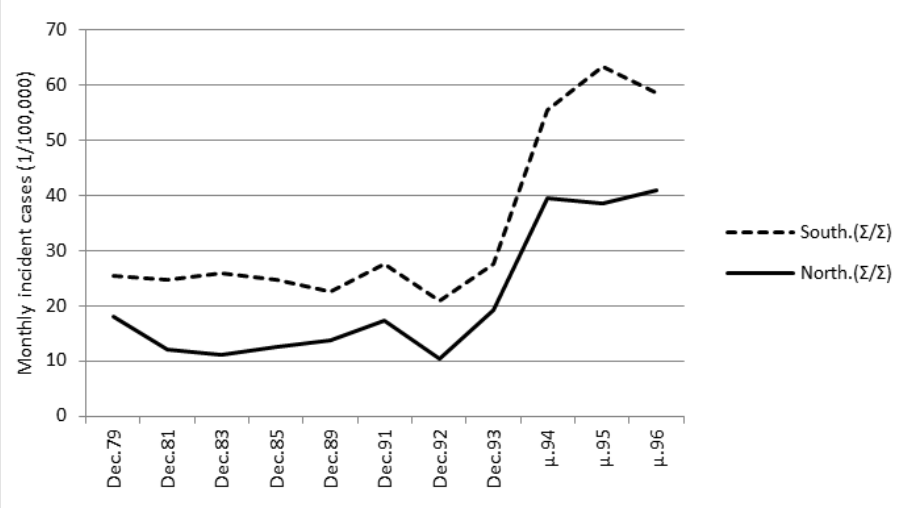

Figure 2: Incidence of HMg in southand North Finland.

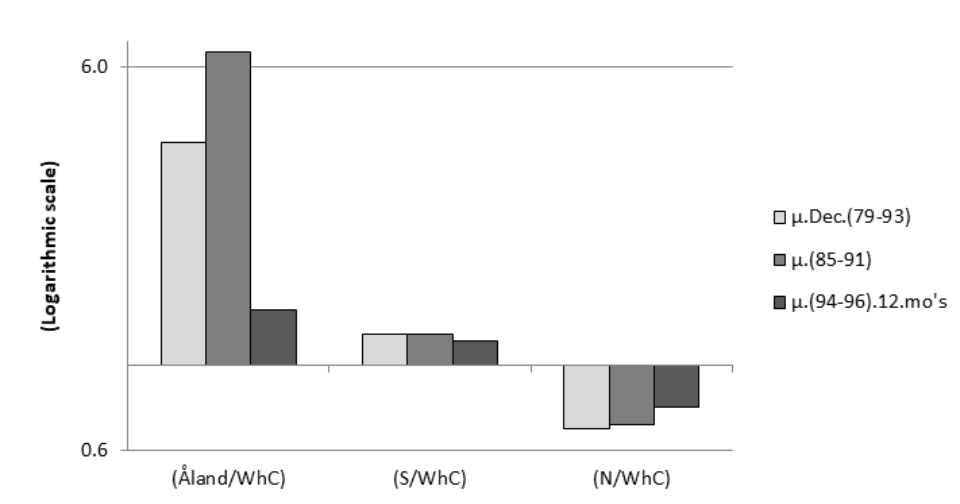

Figure 3: HMg incidence ratios: Aland/WhC), (South/WhC) and (North/WhC), during periods 1979-93,1985-91 and 1994-96.

Table 6: Incidence of Par

Associations of periodical HMg values with each other [(1994-96), (1979-93)] and with (Mg/Ca).soil	
Pearson{HMg.[(79-93);(94-96)]}	0.68*
Pearson[(Mg/Ca);µ.HMg.(79-96)]	-0.48
Pearson[(Mg/Ca);µ. HMg.(79-93)]	-0.41
Pearson[(Mg/Ca);µ. HMg.(85-91))]	-0.62*
Pearson[(Mg/Ca);µ. HMg.(94-96))]	-0.50

Table 7: Significance levels of Pearson correlation (N = 10).

Significance levels of Pearson correlation (N = 10)			
abs(R) >	0.574	:P<0.05	*
abs(R) >	0.696	:P<0.01	**
abs(R) >	0.800	:P<0.001	***

Table 8: HMg incidence ratios: Åland/WhC, South/WhC and North/WhC, during periods 1979.

HMg incidence ratios: Åland/WhC, South/WhC and North/WhC, during periods 1979			
	(Åland/ WhC)	(S/ WhC)	(N/ WhC)
µ.Dec.(79-93)	3.82	1.20	0.68
µ.(85-91)	6.58	1.20	0.70
µ.(94-96).12.mo's	1.39	1.15	0.77

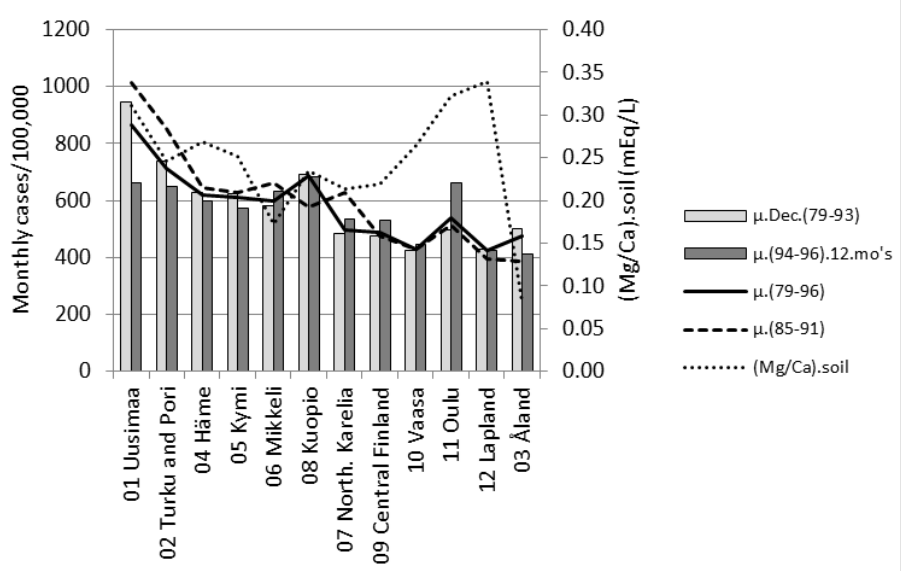

Figure 4: Hypocalcaemia in four periods and (Mg/Ca)Soil.

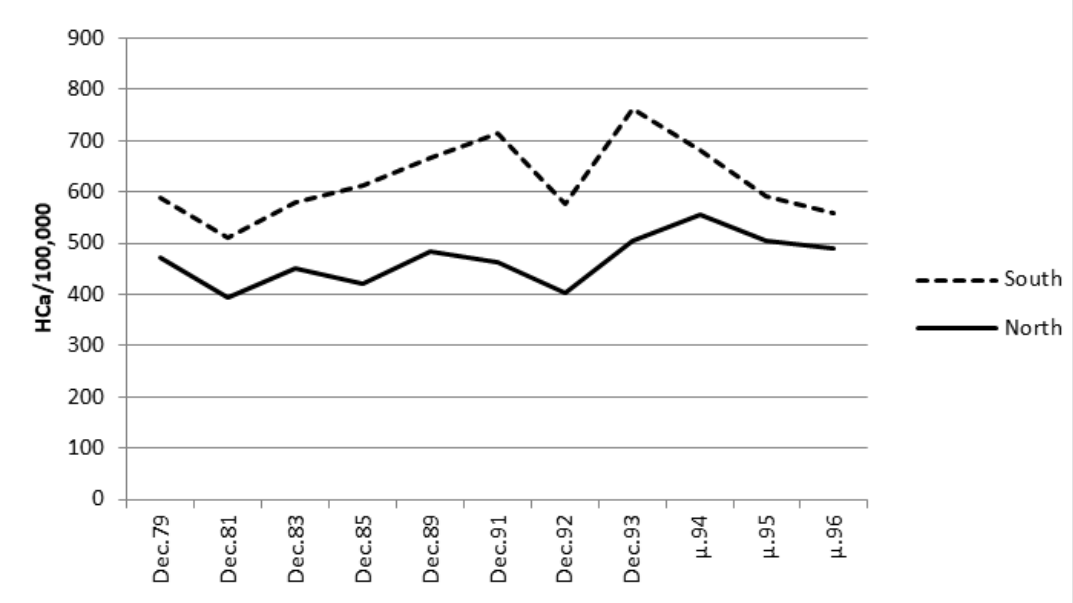

Figure 5: Incidence of HCa in South and North Finland.

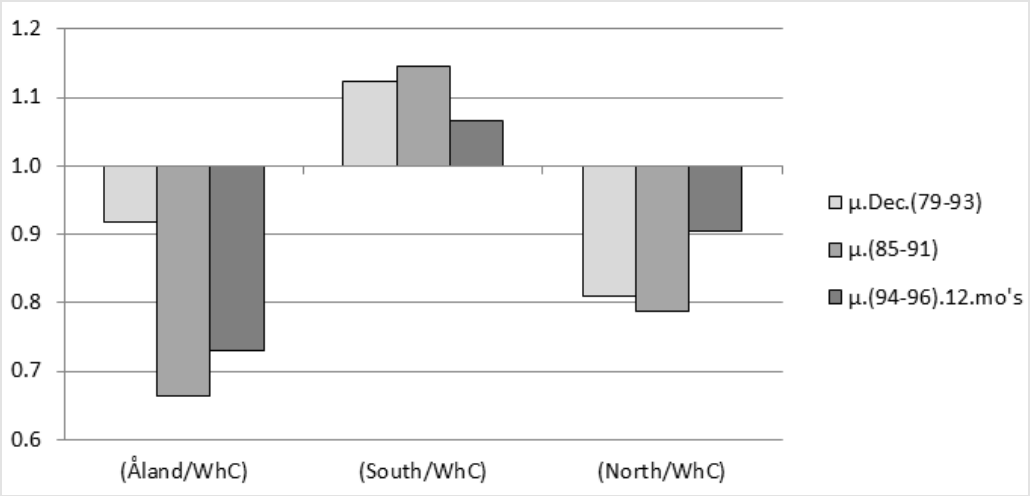

Figure 6: HCa incidence ratios: Aland/WhC), (South/WhC), (North/WhC) in three periods.

Table 9: Parturient hypocalcaemia (HCa)/100,000. Calculated by data in Tables 2 and 4.

Parturient hypocalcaemia (HCa)/100,000. Calculated by data in Tables 2 and 4.															
	01 Uusimaa	02 Turku and Pori	04 Häme	05 Kymi	06 Mikkeli	08 Kuopio	07 North. Karelia	09 Central Fin-land	10 Vaasa	11 Oulu	12 Lapland	03 Åland	South.(Σ/Σ)	North.(Σ/Σ)	HMg.(S/N)
Dec.79	941	641	668	540	469	868	368	377	446	496	521	537	590	473	1.25
Dec.81	707	601	495	626	455	616	285	422	404	394	323	714	511	392	1.30
Dec.83	1027	656	679	545	347	951	275	366	431	468	472	525	579	449	1.29
Dec.85	1016	821	511	682	520	518	501	581	462	418	191	318	612	421	1.46
Dec.89	956	840	704	612	667	608	644	376	366	629	656	361	666	485	1.37
Dec.91	1077	895	725	587	798	599	739	463	464	499	338	485	715	464	1.54
Dec.92	885	734	477	597	583	520	497	503	380	446	376	582	578	402	1.44
Dec.93	945	705	762	797	822	841	551	703	432	608	539	468	762	503	1.51
μ.94	769	754	680	707	643	713	624	570	483	695	475	339	681	555	1.23
μ.95	634	647	566	553	630	677	495	494	424	662	416	507	592	505	1.17
μ.96	585	552	543	460	625	660	480	521	424	624	378	392	558	489	1.14
μ.(79-93)	944	737	628	623	583	690	482	474	423	495	427	499	627	449	1.39
μ.(79-96)	867	713	619	609	596	688	496	489	429	540	426	475	622	467	1.34
μ.(85-91)	1016	852	647	627	662	575	628	473	431	515	395	388	664	456	1.46
μ.(94-96)	662	651	597	573	633	683	533	528	443	660	423	413	610	516	1.18

Table 10: Associations of periodical HCa values with each other [(1994-96), (1979-93)]and with (Mg/Ca)soil.

Associations of periodical HCa values with each other [(1994-96), (1979-93)] and with (Mg/Ca).soil	
Pearson{HCa.[(79-93);(94-96)]}	0.80**
Pearson[(Mg/Ca);μ.HCa.(79-96)]	0.20
Pearson[(Mg/Ca); μ.HCa.(79-83)]	0.11
Pearson[(Mg/Ca); μ.HCa.(85-91)]]	0.23
Pearson[(Mg/Ca); μ.HCa.(94-96)]	0.26

Table 11: HMg incidence ratios: Åland/WhC, South/WhC and North/WhC, during periods 1979.

HMg incidence ratios: Åland/WhC, South/WhC and North/WhC, during periods 1979			
	HCa.(Åland/WhC)	HCa.(S/WhC)	HCa.(N/WhC)
µ.Dec.(79-93)	0.870	1.078	0.767
µ.(85-91)	0.642	1.086	0.741
µ.(94-96).12.mo's	0.735	1.034	0.899

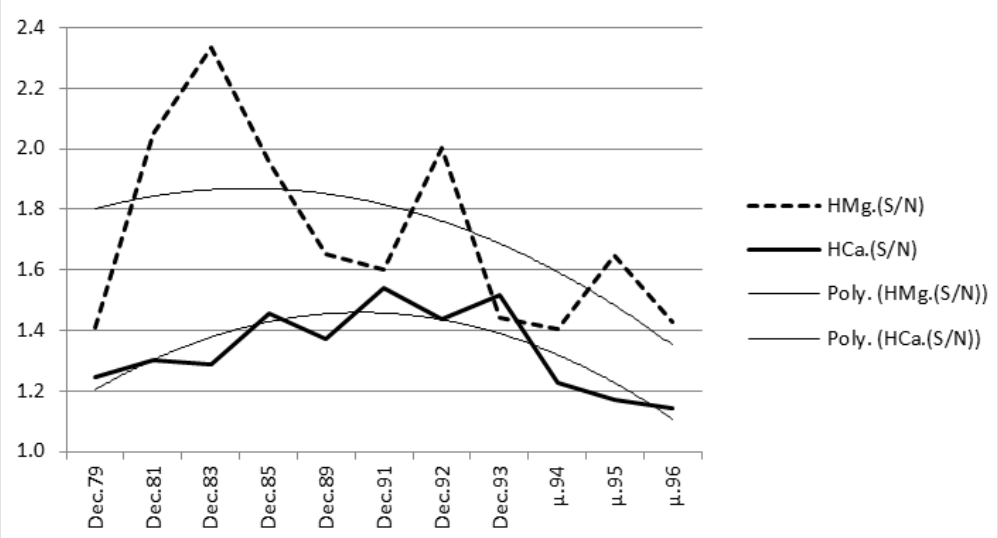

Figure 7: South/North ratio of HMg andHCa during 1979-96.

Results in Short

[(Mg/Ca).soil] explained [HMg.(85-91)] negatively by 38 % (p = 0.032) (Figure 8). Small number of samples can cause statistical bias. HMg cases are about coincidental with soil samples(Figures 9&10).

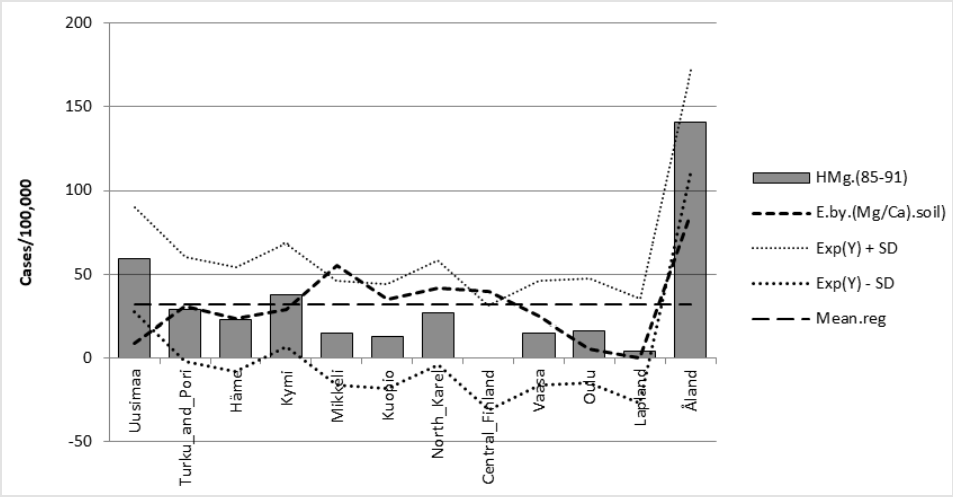

Figure 8: Hypomagnesemia incidence in 1985-91 and its regression by cropland Mg/Ca ratio- negative association.

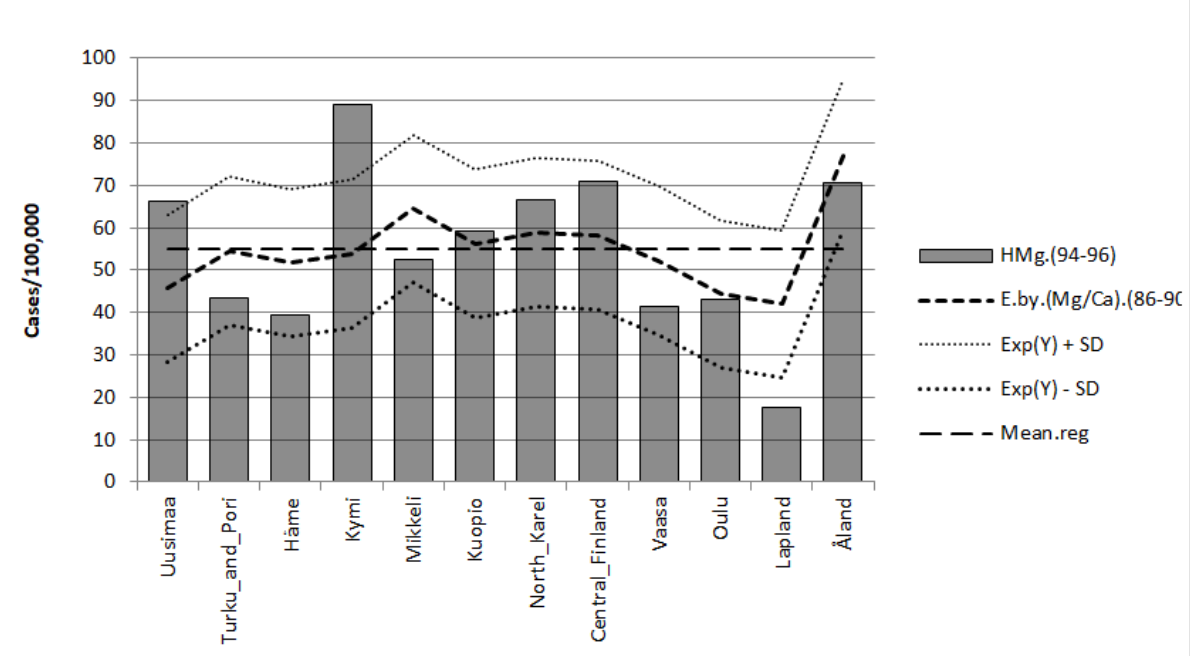

Figure 9: Hypomagnesemia and its regression by cropland Mg/Ca ratio- negative association.

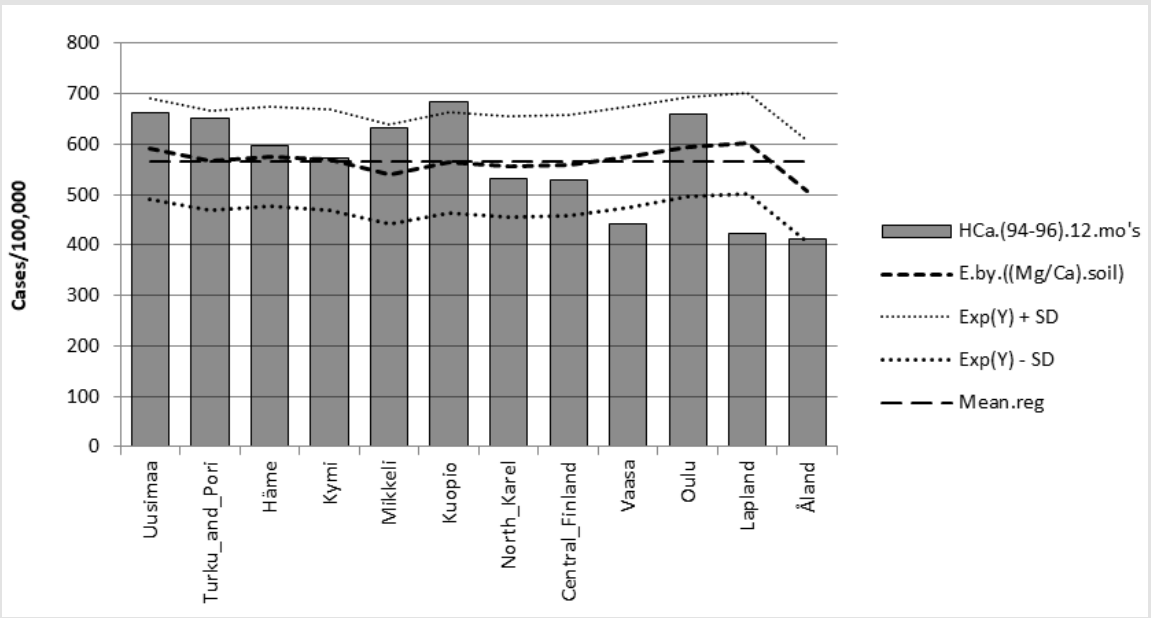

Figure 10: Hypocalcaemia and its regression by cropland Mg/Ca ratio- negative association.

Discussion

This study shows that HMg was associated trend-like negatively and HCa weakly positively with agricultural soil Mg/Ca ratio as suggested by [4-6]. Strongest HMg association (-0.62*) with [(Mg/Ca).soil] was observed, when HMg cases were collected from about the same period. South and Nord was selected differently to [7] (Nord exluded Kuopio and included Vaasa), because of higher Mg/Ca ratio in 1986-90 than in 1966-70. Soil (Mg/Ca) ratio in South was lower to North: S/N ratio was below 1 (0.82-0.83) even by weighting the soil values by the number of cows. Compliance between South and West values in HMg and HCa is obviously partially dependent on climatic factors. Assessing by South and North blocks can include additional bias although it could reduce statistical biases. Small number of variables (12) and small size of

variables, as well as small number of provincial HMg cases in 1979-93 could cause statistical bias. The moderately big changes in soil values during the scope of this study [7] could have affected on the results [7]. Veterinary surgeon Haaranen[16] did not see any HMg cases during 1953-66 in his district (in Kuopio province – "North") although HMg was common in Finland before availability of Mg-rich fodder salts, since 1956 [17]. HMg risk was changed via NPK/Mg fertilization ratio [16], even associated with phosphor proportion in fodder [16]. HMg risk was obviously affected via (domestic or foreign) fodder import. Explanation for higher HMg risk in Kymi to Åland after 1992 (Table 5)is not explained here. Different roles of soil and groundwater factors are discussed in [7]. Outside of this study groundwater Mg/Ca ratio associated non-significantly negatively with HMg and positively with HCa. But water-factors seem to have difficulties in explaining their effects quantitatively.

Conclusion

Association of cropland Mg/Ca ratio with HMg and HCa was similar but much weaker than suggested by the soil timothy studies in the 1970's. As a background phenomenon soil Mg/Ca could affect slightly on Ca and Mg balance of animals and humans, negatively and positively. Comparing of HMg and HCa incidence especially in carbonate soils are suggested.

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