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Studies on 'the Utrecht Abnormality of Milk' in the Miyuki Dairy Farm IV. Occurrences of 'the Utrecht Abnormality of Milk', Osteoporosis, Grass Tetany and Milk Fever on the Chronic Magnesium Deficient Herd.

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(Figs. 1–3, Tables 1–4, Plates 1–16)

Metabolic disorders such as osteomalacia, ketosis, hypocalcaemia and hypomagnesaemia have been studied extensively in laboratory animals and in farm animals. There have been delivered many reports on spontaneous hypomagnesaemia and grass tetany in ruminants (Voisin A., 1963)[8]. Yet nothing is known about the effect of Mg-deficiency except hypomagnesaemic tetany in ruminants. There have been already many reports on bone diseases, but nothing yet about osteomalacia in lactating dairy cows.

The present paper deals with studies made on a certain dairy herd which has been secreting a great deal of abnormal milk, so-called "the Utrecht abnormality of milk", and of course that have been suffering from chronic metabolic disorder of bone abnormality of "osteoporosis" and "low-serum-Mg" related to a shortage of magnesium in the rations. Ketosis has frequently occurred in this dairy herd, ketosis which, in this case, is also closely related to Mg-metabolism (Yoshida S., 1978, 1979)[13,14]. Grass tetany and milk fever also have occurred in this dairy herd.

Miyuki Dairy Farm, located in Fukuyama City, Hiroshima Prefecture, Japan, consists of 17ha of grass land and 20 dairy cows. In 1970, it was discovered that all of the lactating dairy cows of this dairy farm had been secreting milk showing alcohol-test-positive, and most milk samples was showed up heat-test-positive. The author paid attention to this phenomena, and after estimation of the Ca and Mg contents in their abnormal milk and blood samples, he diagnosed it as a case of chronic lactation disorder accompanied by osteomalacia and low-serum-Mg.[10, 11] The author also diagnosed that this frequent occurrence of abnormal milk agreed with the phenomenon in the Netherlands called "the Utrecht abnormality of milk".[6] So he had been closely following up this pathological herd.

EXPERIMENTALS

Animals : The herd used in this experiment were 20 lactating dairy cows of Miyuki Dairy Farm as shown in previous paper.[12] The abnormality in these cows was found out by the alcohol-test-positive abnormal milk secretions from all the lactating cows in that dairy farm. This abnormal milk is not suitable as material for milk processing in according to the Japan Agricultural Standard.

For the normal ones, samples from 54 healthy cows secreting normal milk were obtained from various other dairy farms located in the vicinity of the dairy farm mentioned

above.

Blood samples: Blood samples were invariably taken from the jugular vain. Determination of chemical and biochemical values were identical with the methods described in previous work.[13]

RESULTS AND DISCUSSIONS.

Great abnormalities occurred on the Miyuki Dairy Farm at the midsummer of 1970. All the lactating dairy cows of this herd secreted milk showing alcohol-test-positive and heat-test-positive properties. This phenomenon seemed to be analogous to "the Utrecht abnormality or instability of milk" of the Netherlands in nineteen thirties.[6] Besides this, other abnormalities were the frequent occurrence of "disturbance of parturition" and "ketosis". Ketosis has frequently occurred, 15 of the 20 cows fell into ketosis at the same time in August 1971, as reported in a previous paper.[13] Paresis was seen 12 times in 144 calving during 8 years from 1964 year of the opening of the dairy farm until 1971. 11 times abortion and 8 times still-birth occurred in this dairy farm and 8 cases of retain of the placenta were taken up by veterinary surgeons.

Table 1. Serum & whole blood values of Miyuki Dairy Farm and Normals. All blood samples were collected in October 1970.

		Mean average for Miyuki DF	Mean average for Normals	T-test
Number of cows		18	54	
Whole blood	Ca (meq/l)	3.84	3.34	$P < 0.01$
" "	Mg (meq/l)	1.82	1.85	N.S.
Blood serum	Ca (meq/l)	4.48	4.24	$P < 0.01$
" "	Mg (meq/l)	1.82	2.00	$P < 0.01$
" "	Pi (mg/dl)	6.38	7.41	$P < 0.02$
" "	total protein(%)	8.53	7.68	$P < 0.02$
" "	albumin (%)	2.81	2.90	N.S.
" "	globulin (%)	5.72	4.78	$P < 0.02$
" "	ALPase (K.A. unit)	4.11	4.22	N.S.

Table 2. Serum glucose content of Miyuki Dairy Farm and Normals. All Blood samples were collected in November 1970.

	Mean average for Miyuki DF	Mean average for Normals	T-test
Number of cows	16	13	
Blood serum glucose (mg/dl)	49.1 (35.2-57.3)	60.6 (54.0-80.5)	$P < 0.01$

* 20mg of NaF was added to 10ml of blood samples

With these preliminary remarks in view, blood samples were collected from the abnormal and from the normal cows. Because there had been some cases of bone disease, the serum Ca, Mg, Pi content and the alkaline phosphatase activity were determined. Serum albumin and globulin were also determined to examine the relation with bone abnormalities. Table 1 shows the results for serum values and Ca, Mg levels for whole blood samples. Serum glucose contents are shown in Table 2. Details of serum Ca and Mg, whole blood Ca and Mg were already shown in a previous work.[11] It can be seen that the mean values for Miyuki Dairy Farm show lower concentrations than the normal values, such as serum Mg and Pi, and in the higher concentrations such as serum Ca and whole blood Ca. The serum total protein is in the higher level and the serum globulin is also in the higher level. The serum glucose content is in the lower level for pathologicals.

From these results, such as low-serum-Mg, low-serum-Pi high-serum-protein and globulin, it appears that the herd suffering from "the Utrecht abnormality of milk" is clearly different from the normally lactating dairy cows.

The characteristic signs of these abnormal cows are just the shortage of serum Mg. The serum Mg level for these cows is fairly low. The differences are small and yet should not be overlooked. The details of the blood samples of the herd were described in previous work from October 1970 to October 1971.[2]

The serum alkaline phosphatase activity was especially taken into attention in the

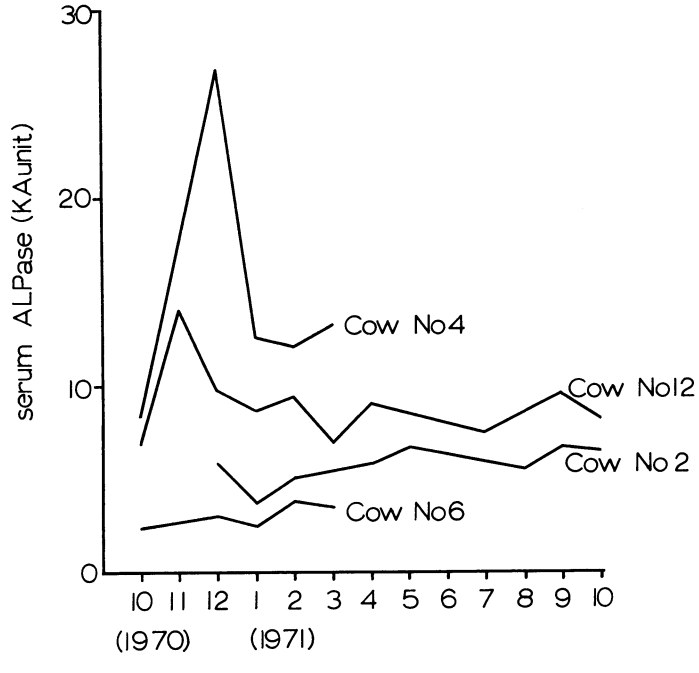


Fig. 1 Changes of blood serum alkaline phosphatase activity on osteoporotic cows. Cow No. 2 and No. 6 were normal ALPase activity and their bone showed osteoporosis, and Cow No. 4 and No. 12 were high levels in ALPase but osteoporosis as shown in plates. Normal range of bovine surum ALPase is estimated between 3 to 7 king-armstrong unit.

diagnosis of osteomalacia or other bone diseases. At the times of richet and osteomalacia,[5] increased quantities of ALPase activity were seen. Although there were some reports that osteoporosis did not lead to serum ALPase elevation.[1), 2)] However, all bone samples collected from Miyuki Dairy Farm showed the typical characteristics of osteoporosis and some cows showed low serum ALPase activity, other cows showed higher values during the whole year and some showed an abnormal elevation in the winter season, as shown in Fig. 1.

All cows either old or young, were suffering from osteoporosis as after slaughter experiments proved, as shown in the plates. Many small brown spots were observed on the compact bone caused by congestion of capillaryvessel in the Harversian canal (Plate ld). This phenomenon was seen on the bones of the whole body especially on the vertebrae, the ribs, and the jaw bone. Partially, the bone turned porous (Plate 4c) and easily fracturing, and some bones showed bone atrophy (Plate 3). Some jaw bones of young cows due to serious sick of their mother had thin and weak bones as shown in the plates (Plate 6a & 6b). X-ray and histological study of bone samples also showed the occurrence of osteoporosis as shown in the plate (Plate 2).

It is said[9] that osteoporosis is associated with stone disease only during periods of prolonged inactivity of the patient, during such times which urinary calcium excretion increases. Some cows showed much sand in the kidney and another cows had renal calculous (Plate 11 & 12).

Some cows had large or small bubbles, so-called hydronephrosis as shwon in the plates (Plate 13 & 14). The histological examination of the kidneys showed sclerosis, chronic interstitial nephritis, and cyst of glomerulus (Plate 15 & 16).

Some cow had amyloidosis on the liver.

Occurrence of grass tetany amongst these osteoporotic cows was observed too in this dairy herd. Cow No 12 was a lactating Holstein of 600kg body weight. It was found out that this cow was suffering from osteoporosis and showed an interesting movement on blood serum ALPase as shown in Fig. 1. At the biginning of these observations, her bone disease was not so serious because the nutritive conditions were good and the abnormality was an occurrence of ketosis, "the Utrecht abnormality of milk" only alcohol-test-positive not heat-test-positive, and one abortion at 4th calving. After the 7th calving in Autumn of 1973, she fell into paresis accompanied with a slight convulsion of the hind legs and semicoma with dull eyes. Her appetite fell off two days before she got paresis. At first, the veterinarian diagnosed milk fever and after collection of a blood sample he gave an injection of calcium borogluconate. The cow recovered from her paresis. After the analysis of the blood sample, it appeared clearly that the cow had contracted grass tetany accompanied by a typical pattern of hypomagnesaemia, as shown in Table 3. The same conditions of paresis with convulsions had occurred twice previously in this dairy farm but never had there been a present of occurrence of grass tetany. The bone sample further more showed the occurrence of osteoporosis and the kidneys indicated hydronephrosis, as shown in the plate (Plate 9a, 9b & 11).

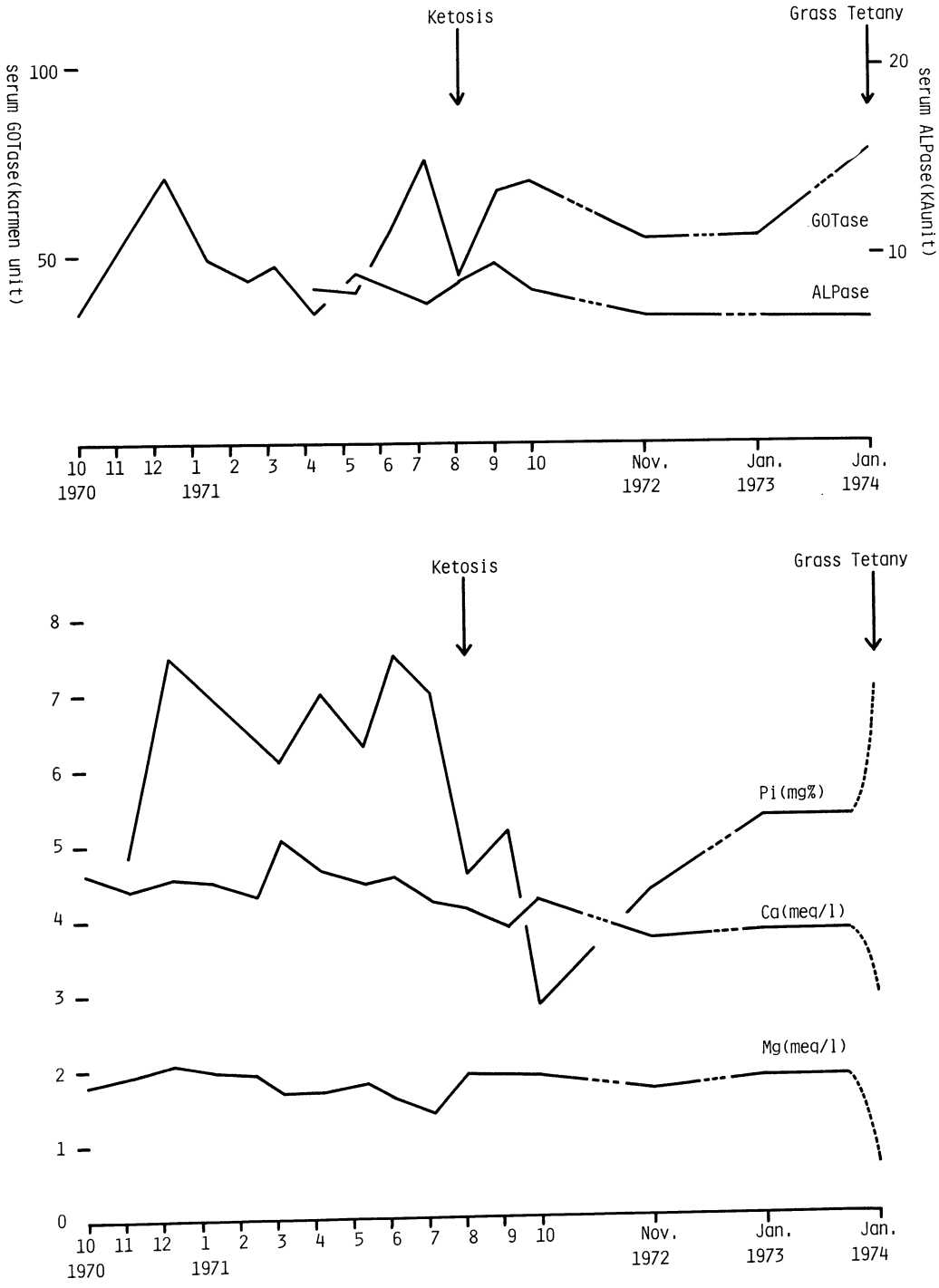


Fig. 2 Occurrence of ketosis & grass tetany on osteoporotic Cow No. 12 and it's blood serum observation.

Table 3. Blood serum pattern of Cow No.12 with grass tetany.

		1972 Nov. 13	1973 Jan. 12	1974 Jan. 21 (at grass tetany)
Blood serum	Ca (meq/*l*)	3.70	3.78	2.92
	Mg (meq/*l*)	1.68	1.84	0.64
	Pi (mg/d*l*)	4.33	5.32	7.01
	ALPase (K. A. unit)	6.74	–	6.53
	GOTase (Karmen unit)	54.0	54.5	77.5
	glucose (mg/d*l*)	57.3	63.2	95.1
	pyruvate (mg/d*l*)	0.33	–	0.33
	α-ketoglutarate (mg/d*l*)	–	–	0.28
	albumin (%)	3.21	–	–
	globulin (%)	5.80	–	–

The occurrences of milk fever in these osteoporotic cows was observed too in this dairy herd. Cow No.1 was a lactating Holstein of 530kg body weight, her last calving, the 13th, had been on July 15, 1971. It was found that this cow too was suffering from osteoporosis, she was kept under close observation in order to follow the metabolic disorder. Blood samples were collected monthly from 1970 to 1971. One week before and after her 13th calving, blood samples were also collected, (i.e., July 7, before calving and July 23, after calving). Two weeks after her last calving, she fell into paresis accompanied with the typical clinical symptoms of milk fever, such as narcosis and kink in the neck. After the collection of blood samples she was slaughtered. A few days before she got paresis, she had been seen standing vacantly and isolated herself from the group. At the time of paresis, the blood serum sample showed hypocalcaemia and a normal serum Mg level but her serum showed a low level of Mg up to that time, as shown in Table 4 and Fig. 3. The bone samples also showed osteoporosis as shown in the plate (Plate 4a, 4b & 4c).

The characteristic signs observed in Miyuki Dairy Farm were:

1) teeth abnormalities such as broken incisors, abnormal defacement, abnormal pattern on surface of incisors, brown tartar, etc.
2) articular disease, lameness.
3) abnormal skinny and thin condition of hip, reduction of subcutaneous fat, diarrhea or slushy feces.
4) frequent occurrences of paresis, abortion, still-birth, and reproductive disturbance.
5) occurrences of grass tetany, milk fever, ketosis.
6) kidney and liver disturbance.
7) abnormal reduction of milk yield, milk fat and "the Utrecht abnormality of milk" secretion.
8) mineral unbalances in blood serum and whole blood.
9) elevation of serum ALPase and transaminase.
10) osteoporosis.

In regard to the etiology of this osteoporosis, the author came to the conclusion that those cow must have been suffering from chronic magnesium deficiency. The ground,

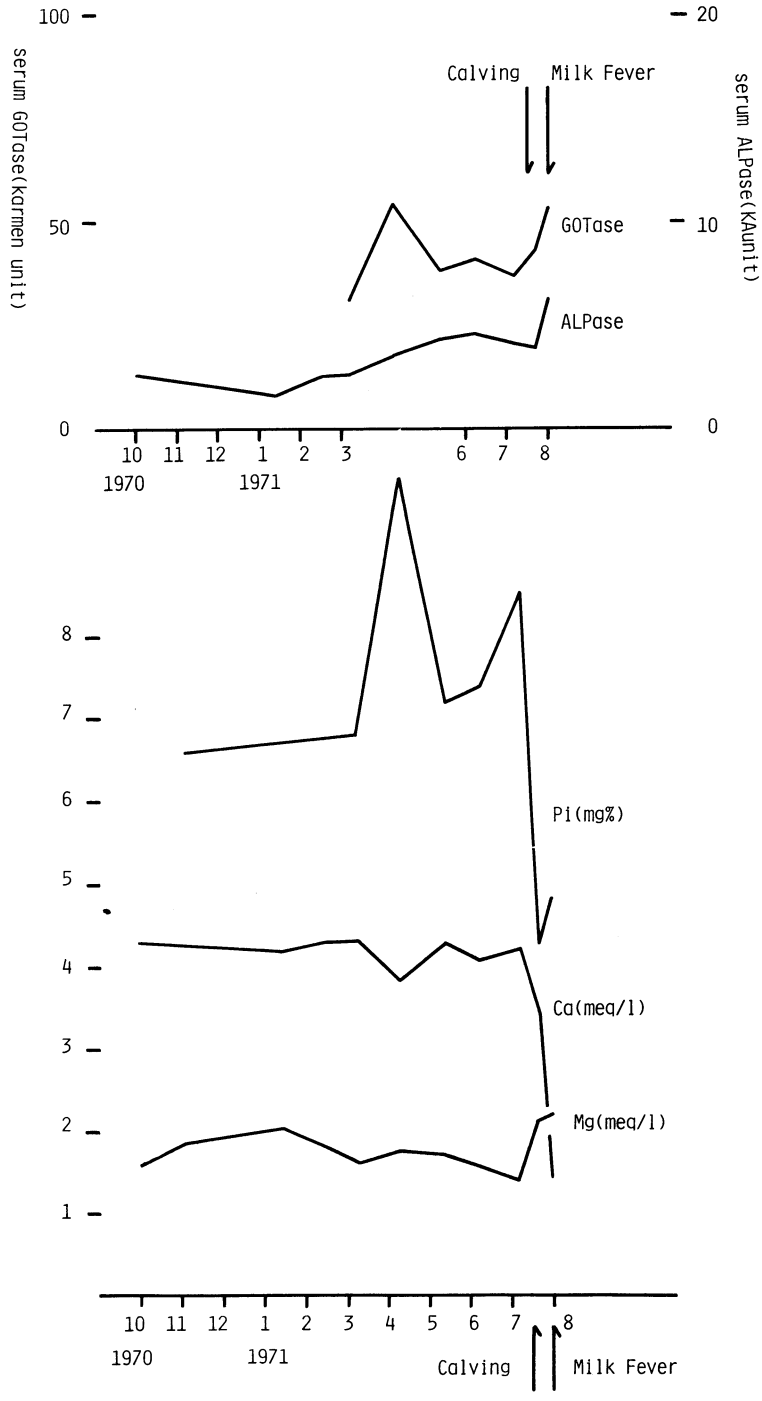


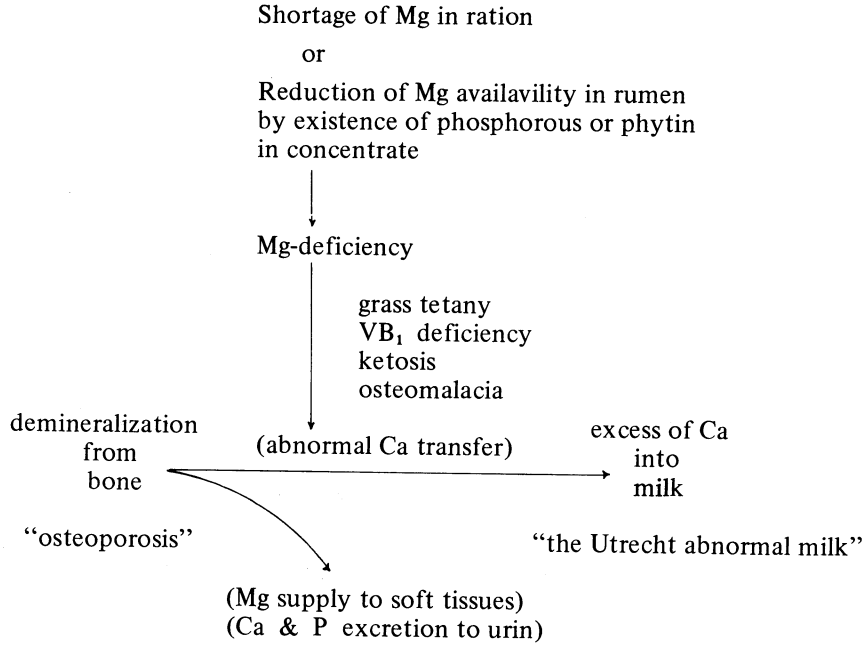
Fig. 3 Occurrence of milk fever on osteoporotic Cow No. 1 and it's blood serum observation.

Table 4. Blood serum pattern of Cow No.1 with milk fever

	1971 Jul. 7 (one week before calving)	1971 Jul. 23 (one week after calving)	1971 Jul. 31 (with milk fever)
Blood serum Ca (meq/*l*)	4.21	3.41	1.42
Mg (meq/*l*)	1.39	2.12	2.20
Pi (mg/d*l*)	8.52	4.26	4.82
ALPase (k.A. unit)	4.1	3.91	6.14
GOTase (Karmen unit)	36.8	42.5	53.0
GPTase (Karmen unit)	12.7	13.0	14.0
albumin (%)	2.87	2.73	2.95
globulin (%)	6.48	5.58	6.35

that Mg-deficiency causes milking cows to fall into osteoporosis, is (1) less Mg but normal Ca and P in the ration, less F in water, (2) low-serum-Mg and hypomagnesaemic tetany, (3) certain disturbances i.e., ketosis, which were cured by Mg-dosing have occurred.

And another hypothesis for osteoporosis and "the Utrecht abnormality of milk" is as follows. When the cow falls into Mg-shortage by absolute shortage intake or by decrease of Mg-utility due to the presence of phosphorus in concentrates, the bone crystal suffers dissolution not only of Mg but also of Ca and P. And then, various soft tissues are supplied with Mg and remaining Ca and P are excreted into the milk and the urine via the mammary glands and the kindneys. As a result, the milk shows "the Utrecht abnormality" by increase of the calcium and the kidneys show a certain abnormality by the accumulation of calcium.



It was said by Seekles etc. in 1947 that [Beside, the typical kind of "the utrecht abnormality of milk", which may probably be related to a luxurious diet, a non-typical one was shown to occur in the Netherlands on account of malnutrition].[6] , and in 1954 [An account is given of "the Utrecht instability in milk", caused by a dietary mineral inbalance, and characterized by an increasing tendency for the casein to flocculate].[7] The author presumes that this dietary mineral unbalance is closely related to bone disease at "the Utrecht abnormality" in the Netherlands, caused by Mg poor grass and P rich concentrates.

The roughage in Miyuki Dairy Farm was rich in grass, mainly Italian rye grass, and a very small amount of clover yielded by a chemical fertilizer for a long time. It is said that the limit of 0.20% Mg in the dry matter of herbage must naturally be considered as valid within the Kemp's observations,[3] because of the occurrence of cows with very low magnesium content of the blood serum and hypomagnesaemic tetany. Most of the grasses, such as, rye grass, orchard, timothy, Kentucky bluegrass, contain magnesium nearby or less than 0.2% in the dry matter of herbage. On the other hand, the legumes, such as, alfalfa and clovers, contain nearby 0.3% magnesium in their dry matter. Developing Kemp's observation , it is satisfactory to consider that legume are essential to the magnesium requirement for milking cow. Luxurious concentrates rich in phosphorous or phytin contents, such as, oilcake, malt, distillers, rice and wheat bran, soybean, etc., are not desirable for ruminants because those phosphates or phytins make the magnesium into an insoluble and unavailable complex in the rumen.

It is estimated that many lactating dairy cows in Japan must be suffering from the same bone disease through restricted roughage and high concentrates. In fact the author also collected bone samples and blood samples from various private dairy farms showing serious osteoporosis and low-serum-Mg.

SUMMARY

A great deal of abnormal milk secretion had been observed in the Miyuki Dairy Farm. This abnormality of milk was similar to a phenomenon that occurred in the Netherlands in 1940 and was called then "the Utrecht abnormality of milk". The milk and blood showed high levels of Ca and low Mg during a whole year. All cows were kept under close observation in order to follow up this lactational disorder.

The characteristic signs observed in the Miyuki Dairy Farm were not merely abnormal milk secretion but also 1) teeth abnormality, 2) articular disease, 3) diarrhea and abnormal skinny hip, 4) frequent occurrences of paresis, abortion, still-birth, and reproductive disturbances, 5) elevation of blood serum alkaline phosphatase, 6) occurrence of ketosis, milk fever and grass tetany.

All bone samples collected from the herd showed serious osteoporosid with many small brown spots on the compact bone caused by congestion of capillaryvessel in the Harversian canals. Partially, the bone turned porous and easily fractured, and some bones atrophy. Kidney abnormalities such as stone disease, hydronephrosis, sclerosis were seen.

In regard to the etiology of the osteoporosis in the Miyuki Dairy Farm, it was proved that those cows were suffering from chronic magnesium deficiency with chronic bone disease and low-serum-Mg, subacute metabolic disease of ketosis and acute metabolic disturbances of grass tetany and milk fever, caused by the shortage of magnesium contents in herbage, less than 0.2% in the dry matter of herbage. When the cow falls into Mg-shortage, the bone crystal is dissolved not only Mg but also Ca and P, and various soft tissues are supplied with Mg and the remaining Ca is excreted into milk and urine. From this, the bones show osteoporosis by demineralization and the milk shows "the Utrecht abnormality" through the increase of Ca.

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御幸牧場に発生した低酸度二等乳に関する研究

吉田　繁

1970年の夏に広島県福山市北部に位置する御幸牧場において，全ての泌乳牛が，新鮮な牛乳であるにもかかわらずアルコール試験で凝固すると云う，異常乳の集団発生がみられた。この異常乳は低酸度二等乳とも云われるが，1930～1940年代にオランダを中心に発生した“the Utrecht abnormality of milk”と全く同一の現象である。

御幸牧場の異常乳の乳中のCa／Mg比が高くこれは乳中にCaが多くMgが少いが，血中のCaが高くMgが低くくこれらの乳牛群がCa及びMg代謝障害に罹患していることから飼料に起因する乳牛の骨疾患の発生が推定された。

御幸牧場では1964年に牧場を開設してから1971年までの7年間に144回の分娩がみられたが，起立不能症12回，流産11回，死産8回，後産停滞8回と分娩時の障害が多発し，1970年夏季には20頭のうち15頭が同時にケトージスにおち入った。関接障害，歯牙の異常，痩削，腰萎，下痢，繁殖障害，跛行など骨疾患の発生をうらづける症状がみられた。血中のアルカリ性フォスファターゼ活性は骨疾患のときに上昇するが，高い値を示すものがみられ，また冬季に急に上昇するような現象もみられた。淘汰された乳牛から得られた骨は初産の若いものから13産の老齢なものまで全て骨粗鬆症の発生がみられ，主として外側緻密質に赤色点密発し，これはハーバース氏管中の毛細管が充血している為である。腎結石，水泡腎，腎萎縮のような腎障害も多発していた。血清Mgは低い状態にあったが，極端にMg含量の低下するhypomagnesaemic tetanyすなわちグラステタニーの発生及びhypocalcaemiaである乳熱の発生が観察された。

牧草地へN・P・Kを中心とした施肥と，イタリアンライグラス・ソルゴーなどの牧草が主で，Mg・Caの施肥をおこたりクロバーなどのマメ科牧草の不足により，乳牛が慢性的なMg欠乏症におち入り，骨からの脱灰による骨軟症の発生とCaが乳中に多量に移行して異常乳が発生したものと考えられる。

Plate 1a

Plate 1b

Plate 1c

Jawbone of Cow No. 7 (8 calvings) slaughtered on Apr. 1974.

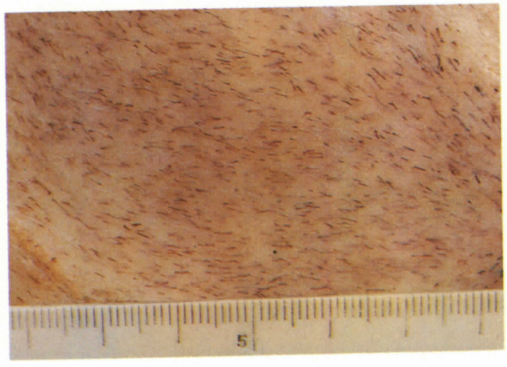

Plate 1d
Congestion of capillary vessel in Harversian canal (Cow No.7).

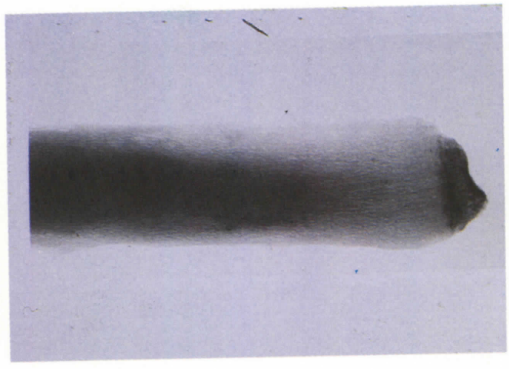

Plate 2
X-ray photograph of rib of cow No.3 (6 calvings).

Plate 3
Atrophy of jawbone of Cow No.3.

Plate 4c
Porous jawbone and brown tartar of Cow No.1.

Plate 4a

Plate 4b

Jawbone of Cow No.1 (13 calvings) slaughtered after serious milk fever on July 31, 1971.

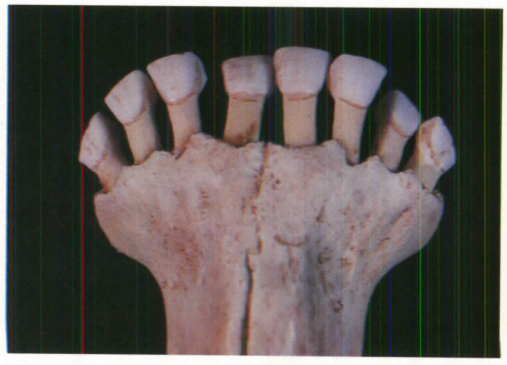

Plate 5a

Plate 5b.

Jawbone of Cow No.2 (7 calvings) slaughtered on Oct. 1971.

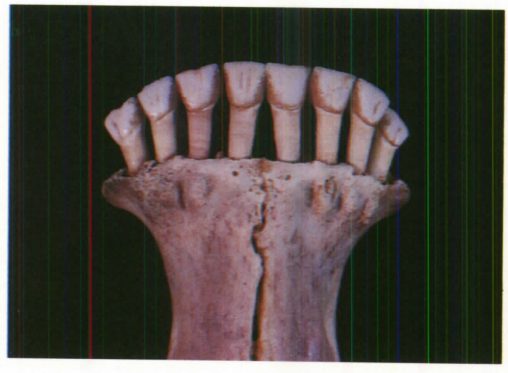

Plate 6a

Plate 6b

Jawbone of Cow No.8 (6 calvings) slaughtered on Apr. 1974.

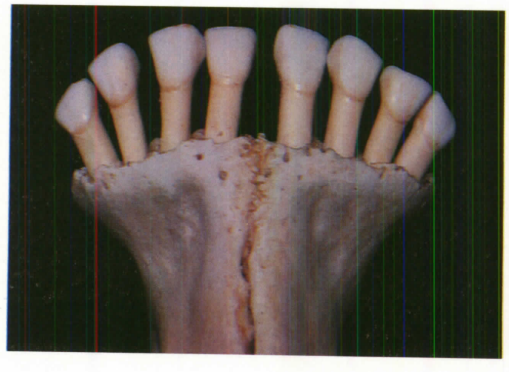

Plate 7a

Plate 7b

Jawbone of Cow No.9 (7 calvings) slaughtered on Jan. 1975.

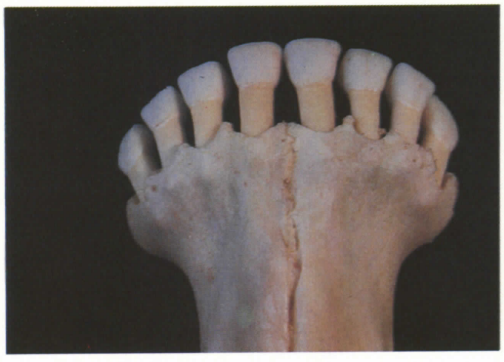

Plate 8a

Plate 8b

Jawbone of Cow No. 10 (7 calvings) slaughtered on Jan. 1975.

Plate 9a

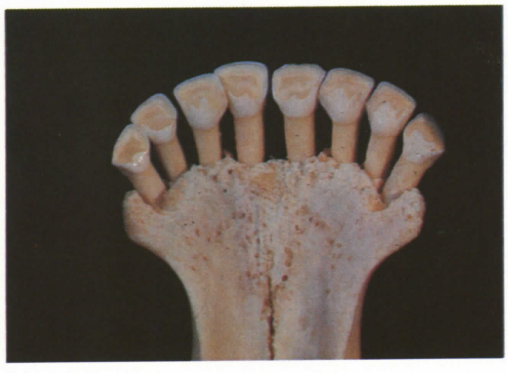

Plate 9b

Jawbone of Cow No. 12 (7 calvings) slaughtered after serious grass tetany on Jan. 1975.

Plate 10a

Plate 10b

Jawbone of Cow No. 19 (5 years old) slaughtered after two times of abortions.

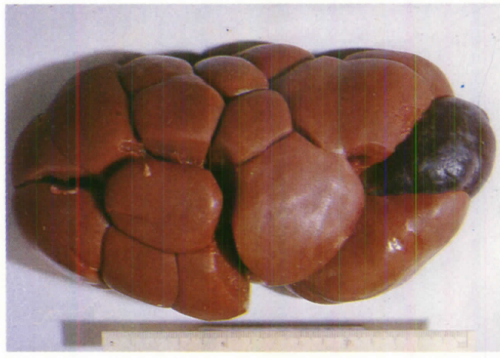

Plate 11
Kidney with large bubble of Cow No.12, (7 calvings) slaughtered after grass tetany.

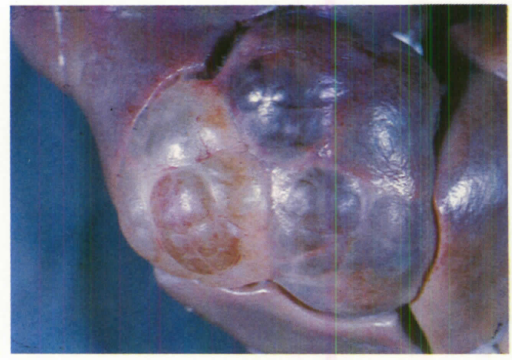

Plate 12
Kidney with large bubble of cow No.30 (1 calving).

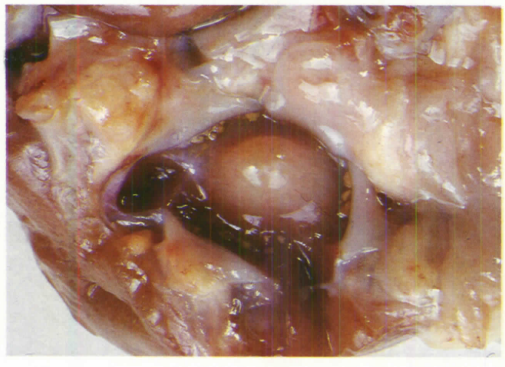

Plate 13
Many sands in kidney of Cow No.4 (6 calvings).

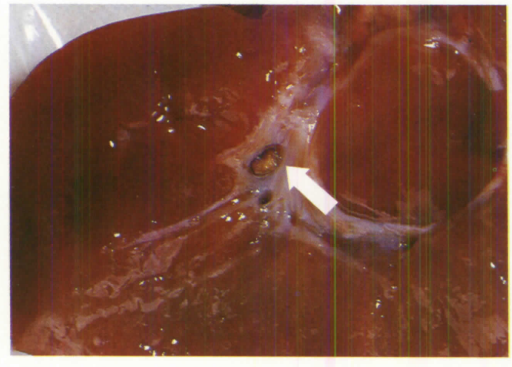

Plate 14
Stone in kidney of Cow No.14 (4 calvings).

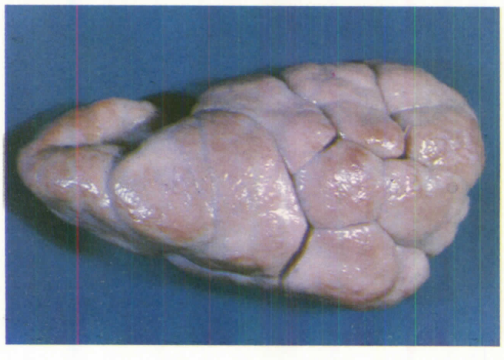

Plate 15
Atrophy and sclerosis of kidney of Cow No.7. (8 calvings).

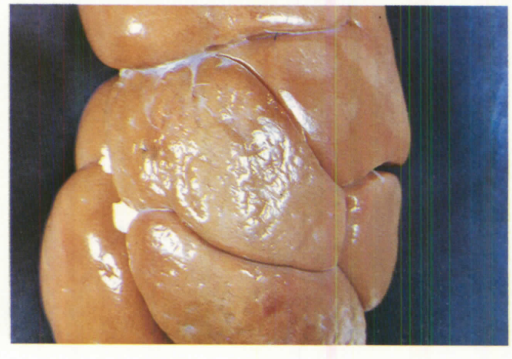

Plate 16
Atrophy of kidney of Cow No.20 (1 calving).