

## 牛の血中ガストリン値と第四胃酸分泌の関係について

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## The Correlation between Plasma Gastrin Levels and Abomasal Acid Secretion in Cows

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**ABSTRACT.** Plasma immunoreactive gastrin (IRG) levels and abomasal acid secretion were investigated on cows with Heidenhain pouch. In two suckling calves (1 month), plasma IRG levels attained at a peak value of 120–160 pg/ml within 3–4 hours after suckling and decreased gradually to about 50 pg/ml by the next suckling. The titratable acidity rose to a peak value of 75–115 mM/l between 3 and 4 hours after suckling and then gradually decreased to the pre-suckling levels (about 20–40 mM/l) between 9–11 hours after suckling. These acid secretory patterns paralleled to the plasma IRG levels. The significant correlation was observed between plasma IRG and total acidity ( $p < 0.01$ ). In a weaned calf (4 months), plasma IRG and acid secretory responses after feeding were indistinct compared with those in suckling calves. Titratable acidity of pre-feeding was 70–110 mM/l and slightly elevated to about 130 mM/l, and subsequently reduced. The significant correlation was also observed between plasma IRG and total acidity ( $p < 0.01$ ). In an adult cow (20 months) fed with roughage only, post-prandial responses of plasma IRG was not observed and the pH value of the secretion is higher than 7.0.—**KEY WORDS:** acid secretion, cow, plasma gastrin.

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There is a close correlation between the post-prandial serum gastrin concentration and the gastric acid secretion in monogastric animals [2]. In the ruminants as well as monogastric animals, the exogenous gastrin was reported to stimulate the abomasal acid secretion [8, 9]. However, physiological role of endogenous gastrin is not elucidated in cows.

Our previous publication reported that the maximum pre-feeding levels were detected in early stage of the rearing period, and that specific post-prandial responses observed clearly in the suckling calves became obscure with growing [10].

This study was designed to investigate the correlation between the endogenous plasma gastrin levels and the abomasal acid secretion of cows in three growing stages.

### MATERIALS AND METHODS

**Animals:** Two Holstein suckling calves A (B.W. 45Kg) and B (B.W. 31Kg) were surgically prepared with Heidenhain abomasal pouch [5], into which a polyethylene canula was inserted to collect secretion. The operation were performed when the calves were 3 weeks old. On the 3rd day after operation, small amount of whole milk warmed at 37°C was suckled from a nursing bottle. The volume of milk given was increased gradually. The suckling calf A was maintained until 4 months of age (B.W. 91Kg) over the weaning, and examined. A Holstein adult cow (20 months old; B.W. 280Kg) was surgically prepared with Heidenhain abomasal pouch. Each experiment was carried out more than 2 weeks

after the operation when the operative invasion was negligible.

**Feeding schedule:** The details of diet are given in Table 1. The suckling calves were given whole milk at 10:00 a.m. and p.m. and were allowed to access to water *ad libitum*. A weaned calf was fed hay with starter and an adult cow was given only hay at 12:00 p.m. and a.m. All animals were allowed free access to water and salt.

**Abomasal acid collection and blood sampling:** Secretion from the pouch were collected from a polyvinyle bag attaching to the pouch canula every 1 hour in suckling calves and 30 min in a weaned calf and an adult cow. At the end of each collection period, blood samples for gastrin assay were drawn as described previously [10].

**Analysis:** Plasma immunoreactive gastrin (IRG) levels were determined by radioimmunoassay described as before [10].

The collected secretion from the abomasal pouch was measured for its volume (ml), and pH with pH meter (TOA HM7A, Tokyo). Titratable acidity was estimated by 10ml portions of the secretion to the endpoint of pH7.0 with 0.1N-NaOH solution. The analysis was performed with an automatic titrater (Hiranuma KOMTIT-7, Tokyo).

The correlation between plasma IRG and total acidity (titratable acidity  $\times$  secretion volume) was also investigated.

Table 1. Daily intake of feed in three age groups

Group	Milk (kg)	Starter <sup>a)</sup> (kg)	Hay <sup>b)</sup> (kg)
Suckling calves (1 month, n=2)	4.0		
Weaned calf (4 month, n=1)		1.9	1.0
Adult cow (20 month, n=1)			7.8

a) TDN=75%

b) Italian rye grass: TDN=56%

## RESULTS

On the 2 suckling calves, diurnal changes in plasma IRG levels and the fluctuation in the volume, titratable acidity and pH value of abomasal secretion are shown in Fig. 1 and 2. Plasma IRG levels rose to a peak value of 120–160 pg/ml between 3 and 4 hours after suckling, and then gradually decreased to the pre-suckling levels (about 50 pg/ml).

The volume of secretion began to increase within one hour after suckling and reached a peak value of 19–25 ml/hour in calf A and 7–13 ml/hour in calf B between 3–4 hours. Thereafter, it declined to the pre-suckling levels (3–5 ml/hour) between 9–11 hours after suckling. The titratable acidity rose to a peak value of 75–115 mM/l between 3 and 4 hours after suckling and then gradually decreased to the pre-suckling levels (about

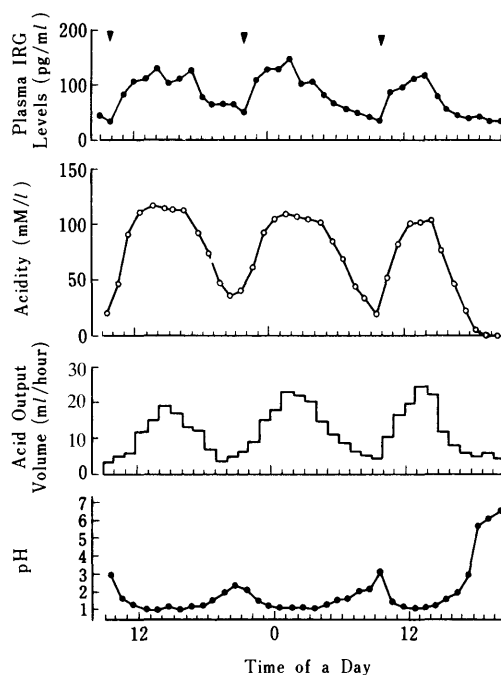


Fig. 1. Diurnal changes in plasma immunoreactive gastrin levels, titratable acidity, acid output volume and pH in a suckling calf A. Milk was suckled at each arrow point.

20–40 mM/l) between 9–11 hours after suckling. The pH of the secretion revealed the lowest value of 1.01–1.08 between 3–4 hours after suckling in both calves, and the value were varied just prior to the next suckling. The volume of secretion and the titratable acidity paralleled to the plasma IRG levels.

The significant correlation was observed between plasma IRG and total acidity in calf A ( $n=34$ ,  $r=0.86$ ;  $p<0.01$ ) and in calf B ( $n=29$ ,  $r=0.73$ ;  $p<0.01$ ). Equation for least squares regression line were  $y=0.0210x-0.734$  and  $y=0.0056x-0.159$ , respectively (Fig. 3).

On a weaned calf, diurnal changes in plasma IRG levels and the fluctuation in the volume and titratable acidity of abomasal secretion are shown in Fig. 4. Plasma IRG levels of pre-feeding (87–180 pg/ml) were higher and the post prandial responses were

indistinct compared with those in suckling calves.

The volume of secretion rose to a peak value of 50–55 ml/30 min between 7–8 hours after feeding and gradually decreased to the basal levels (20–35 ml/30 min) just prior to the next feeding. These fluctuation patterns were similar to those of suckling calves. The titratable acidity of pre-feeding was 70–110 mM/l and slightly elevated (about 130 mM/l) after feeding. The titratable acidity paralleled to the acid volume.

The significant correlation was observed between plasma IRG and total acidity ( $n=66$ ,  $r=0.347$ ;  $p<0.01$ ). Equation for least square regression line was  $y=0.027x+0.321$  (Fig. 5).

On an adult cow, diurnal changes in plasma IRG levels and the fluctuation in the volume and pH value of abomasal secretion

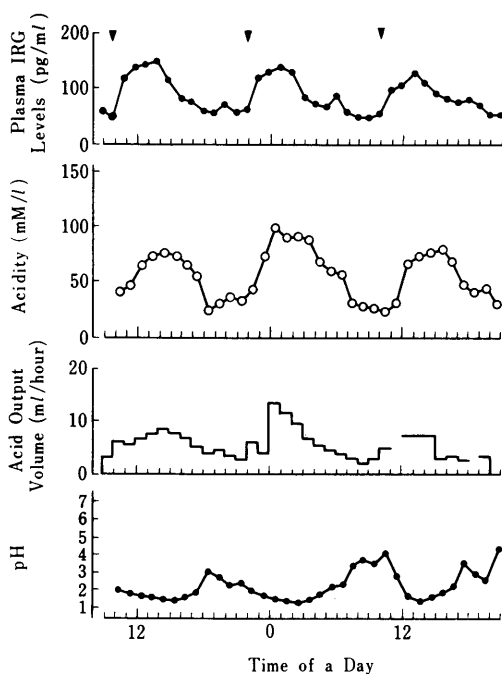


Fig. 2. Diurnal changes in plasma immunoreactive gastrin levels, titratable acidity, acid output volume and pH in a suckling calf B. Milk was suckled at the arrow points.

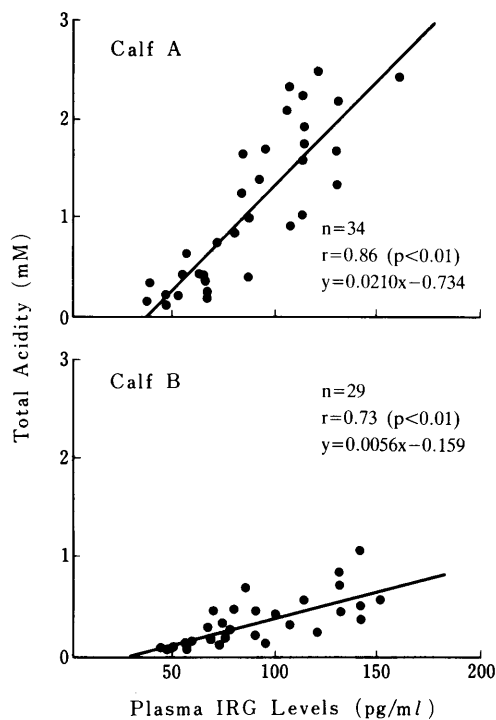


Fig. 3. Correlation between plasma immunoreactive gastrin levels and total acidity in a suckling calf A and B.

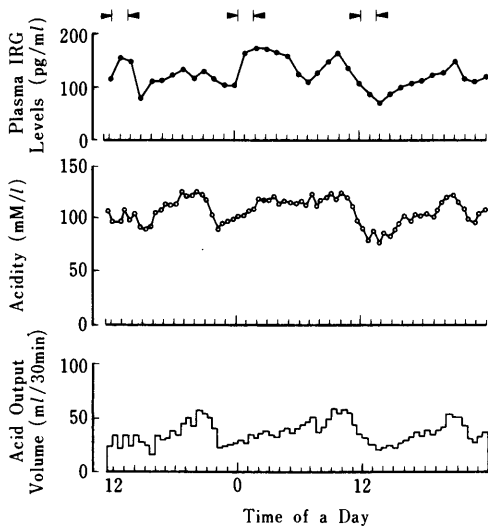


Fig. 4. Diurnal changes in plasma immunoreactive gastrin levels, titratable acidity, and acid output volume in a weaned calf. The feeding periods are indicated by arrows.

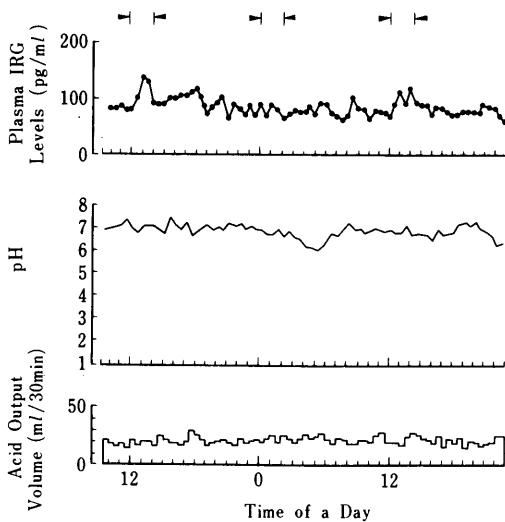


Fig. 6. Diurnal changes in plasma immunoreactive gastrin levels, pH and secretion volume in an adult cow. The feeding periods are indicated by arrows.

are shown in Fig. 6. IRG levels of pre-feeding were 72–96 pg/ml, and its post-prandial elevation was not observed. The volume of secretion was 13–30 ml/30 min and the pH value was very high (6.20–7.64). Neither of the parameters were influenced by the feed intake. Titratable acidity was

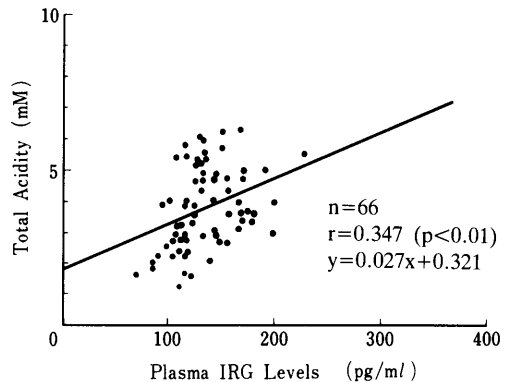


Fig. 5. Correlation between plasma immunoreactive gastrin levels and total acidity in a weaned calf.

undetectable.

#### DISCUSSION

In order to investigate the correlation between plasma IRG levels and abomasal acid secretion, Heidenhain pouch (denervated type) was prepared in this study [5]. Abomasal acid secretory responses of the suckling calves in our study were similar to the results reported by others [7]. These responses paralleled to the plasma IRG levels. Prolonged post-suckling response of plasma IRG might be resulted from the long term accumulation of milk clot in the abomasal lumen.

The gastrin release seems to be stimulated mainly by amino acids, and/or depeptides and tripeptides contained in protein meal ingested [2, 3]. When endogenous gastrin is released, it stimulates HCl and pepsin secretion in abomasum and protein digestion initiates. Subsequently, the further gastrin release ensures following to the accumulation of protein hydrolysates [3, 11]. Hilaire *et al.* [4] investigated the post-prandial acid secretory responses of various meal on Heidenhain dogs, and elucidated the slower initiation of acid secretory response to milk ingestion comparing to other protein meals. According to these facts, delayed initial

gastrin and acid secretory responses observed in calves after suckling may result from contents of free amino acids, and/or depeptides and tripeptides in milk. It was shown on suckling that pH value of abomasal contents rapidly rose up to approach the milk's pH and gradually returned to the pre-suckling level (pH2.0) within 5–8 hours as a result of the acid secretion [7]. In the present study, IRG levels gradually increased for 3–4 hours after suckling, and subsequently reduced. Therefore, in the suckling calves, the inhibition of gastrin secretion by acid appeared to begin at 3–4 hours after suckling.

Because of the high coefficient between plasma IRG and total acidity, the acid secretory responses in suckling calves are under the control of gastrin.

The abomasal acid secretion in sheep fed with roughage was reported to be continuous even when the feeding time was fixed. Since this continuous secretion ceases when the ingesta was prevented from entering into the abomasum by emptying the fore-stomach, it was concluded that the characteristic acid secretory pattern in ruminants is due to the continuous passage of ingesta from the omasum to the abomasum [6]. Furthermore, it was pointed out that the addition into the rumen with 2.5–4.0 l of rumen contents from the other animal caused a increase in outflow from the omasum to abomasum within 5–10 min. This response lasted at least 2 hours [1]. In this study, post-prandial acid secretory responses are observed in weaned calf fed with starter and roughage, though they were not clear like that of suckling calves. Hence the small increase of acid secretion observed just after feeding in the weaned calf was considered to result from the increase in out-flow from omasum. These secretory responses observed in a weaned calf appear to be the transition process from suckling calf to adult cow.

In the present study the acid secretion from the abomasal pouch was undetectable in an adult cow, though it was known that the pH of the abomasal content is 2.0–3.0. It might be resulted from the neutralization by the mucous contained in the secretion.

The effect of gastrin on abomasal acid secretion changed to be obscure with growing from suckling calf to adult cow. In an adult cow fed with roughage only, acid secretory role of gastrin appeared to be small in this study. It is known that in monogastric animals, the post-prandial gastrin and acid secretory responses vary with the composition of the meal. Hence further study on an adult cow is now in progress to investigate the effect of concentrated rations on plasma IRG levels and abomasal acid secretion.

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## 要 約

牛の血中ガストリン値と第四胃酸分泌の関係について：安田和雄・小野憲一郎<sup>1)</sup>・佐々木伸雄<sup>2)</sup>・長谷川篤彦<sup>1)</sup>・友田 勇<sup>1)</sup>(東京大学農学部付属家畜病院, <sup>1)</sup>家畜内科学教室, <sup>2)</sup>家畜外学科教室)——標準的飼養条件下にある哺乳子牛(1ヵ月齢)2頭, 離乳直後の育成牛(4ヵ月齢)1頭および成牛(20ヵ月齢)1頭に Heidenhain の小胃を作製して血中ガストリン濃度(IRG)と酸分泌の関係を検討した。哺乳子牛の IRG は前値の約50pg/mlから, 哺乳後増加して3~4時間には120~160pg/mlに達し, 以後漸減した。滴定酸度は哺乳3~4時間で75~115 mM/lのピークを示した後減少し, 9~11時間には前値に復した。酸分泌は IRG と平行して変動し, IRG と総酸度の間には相関関係が認められた(p<0.01)。育成牛においては, 給餌後の IRG および酸分泌反応は哺乳子牛と比較すると不明瞭であるが, 両者はおおむね平行して変動し, 相関関係が認められた(p<0.01)。成牛では粗飼料給餌による IRG 分泌反応はみられず, 小胃分泌液の pH は7.0以上であった。以上から, 牛においては成長とともに第四胃酸分泌に対するガストリンの影響は小さくなるものと考えられた。