

## Effect of dietary protein level on growth and nitrogen balance in lambs after weaning

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### Abstract

In the present study, the effect of changes in dietary protein level on the growth rate and nitrogen balance were investigated in lambs after weaning. Using 2 twins of lambs weaned at 55 days after birth, each of twins were allocated into two groups, which they were fed high protein (HP) or low protein (LP) diet; 1.8 or 1.2 times of maintenance level respectively. The diet was consisted with timothy hay, rolled barley and soy-protein. Feed intake and body weight were measured daily and weekly, respectively, and the nitrogen (N) balance trial was conducted at 1, 2 and 3 week, and 2, 3 and 5 month after weaning. The daily gain (DG) through the experimental period was 153 and 142 (g/d) in HP and LP groups of Japanese Corriedale lambs, and that was also 235 and 145 (g/d) in HP and LP groups of crossbred (Japanese Corriedale X Suffolk) lambs, respectively. The N consumption was more in HP group than in LP group during the period, and then, N retention in the body was also greater in HP group than in LP group, and these phenomena would reflect on the growth rate in two groups described above. On the changes in N balance during the period, the intake increased but total excretion also increased along with aging, and consequently, the ratio of retention to absorption tended to decrease as a whole. The N retention tended to decrease in LP group, although that tended to increase in HP group along with aging. The retained N per metabolic body weight ( $\text{KgW}^{0.75}$ ) did not change in LP group though it decreased in HP group after 2 month. These findings suggest that the change in the DG of lamb in growing stage is obviously influenced by changes in retained N caused by changes in dietary protein level.

**Key Words:** Dietary protein level, Growth performance, N balance, Lambs,

### Introduction

Ruminant animals let to habit a lot of microbes, *i. e.*, the self-nutritious microbes, in their stomach, so called the reticulo-rumen, and then, their protein metabolism is largely different from other mammals<sup>1)</sup>. The ingested dietary protein is degraded to ammonia by microbes, and further they proliferate using the elaborated ammonia in the rumen, *i. e.*, synthesis of microbial protein. Then, the microbial protein is digested in the lower guts, and further utilized as metabolizable protein in the body. Furthermore, ruminant animals are different from mono-gastric animals, and they are able to use non-protein nitrogen (NPN) to synthesize protein, *i. e.*, they will be able to synthesize high quality-protein from poor protein, such as roughages<sup>2)</sup>. So, the part of ingested protein, such as protein escaped microbial fermentation, and digested but not utilized, will be excreted into faeces as un-absorbed protein. On the other hand, most of absorbed amino acids are used in the liver to synthesize protein to be reserved as body protein, and then, the unabsorbed amino acids and/or driven through degradation of tissue protein in the body would be

converted to urea through ammonia in the liver, and further excreted through kidney into urine<sup>3)</sup>.

The dietary protein absorbed is used to synthesize body protein, and the other side, the body protein is also degraded and excreted into urine as nitrogen (N), *i. e.*, the body protein is in dynamic state; synthesis and degradation will be done simultaneously. Then, in adult animals body protein is mostly maintained at certain level, so called “dynamic balanced situation”, and so their N balance will be zero, *i. e.*, they will be at maintenance period in protein nutrition. On the other hand, the N balance in animals under growing stage could be positive (plus), and in the period of higher degradation than synthesis of body protein, N balance will be surely negative (minus). So this N balance is showing increase and decrease of body protein, and will be an index to judge a condition of protein nutrition, which would be affected with aging, body weight and total nutrition. The synthesis and accumulation of body protein are surely a main event during growing of body, and then the accumulation of protein obviously increases along with a development of body tissues and organs, and consequently, the protein requirement should clearly increase in the growing animals.

Then, in ruminants the development of shape and/or function in the reticulo-rumen should be related to an increase in intake of solid feed after weaning<sup>4)</sup>. In young ruminants, an insufficient intake of solid feed resulted in an imperfect situation of reticulo-rumen function as compared with that in adult ruminants, and then in this circumstance, most of their protein requirement to meet the growth and/or to maintain the physiological functions, could be supplied directly through dietary protein for microbial protein synthesized in the rumen as mature ruminants. Consequently, the quantitative and/or qualitative changes in dietary protein could have related to the changes in absorption, metabolism or deposition of protein in the body of young ruminants, in particular at weaning stage. There are, however, still many points to be cleared about the effects of the changes in system of nutrient intake from mono-gastric type to ruminant-type on protein nutrition, and also the development of the rumen along with growth. In general, it is well known that the difference in level of nutrition fed to the young animals clearly give rise to difference in growth, *i. e.*, the difference in body weight through an increase or a decrease of growth rate, around mature stage externally<sup>5)</sup>.

In the present study, the growth rate and nitrogen balance during growing stage have been investigated after weaning in lambs fed the diets with differing protein level.

## Materials and Methods

### Animals, diets and management

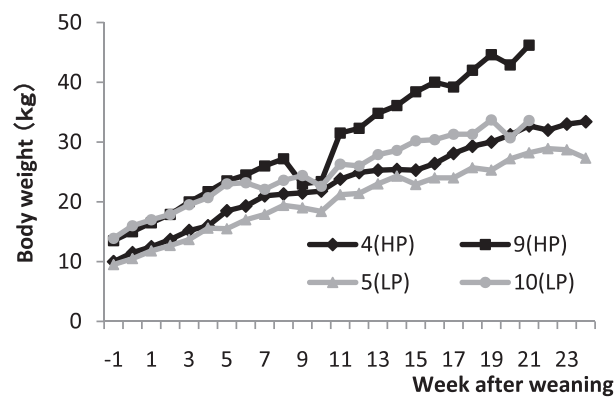
Japanese Corriedale twin female (nos. 4 & 5) and crossbred (Japanese Corriedale X Suffolk) twin female lambs (nos. 9 & 10) were used in the present experiment. They were reared with their dams during suckling period, and they were gradually allowed to eat hays, concentrate and/or starter (pellets) for calves from 2 weeks after birth. Then, they were separated from their dams, and weaned on 55 days after birth, and individually kept in a metabolism crate with wire (net) floor during the entire experimental period. After weaning, each two lambs of the two twins were divided two groups and fed high protein diet (HP: nos. 4 & 9) or low protein diet (LP: nos. 5 & 10) according to the NRC (National Research Council) standard<sup>6)</sup>. The two levels of dietary protein were as follows: HP: 1.8 and LP: 1.2 times of maintenance level, respectively.

Timothy hay and rolled barley was used as main dietary constituents, and soybean protein was used to adjust a dietary protein level delicately (Table 1). The timothy hay and concentrate (barley and soybean protein) were offered separately. Fresh water was freely available, and each lamb had access to a

**Table 1.** Chemical composition of feed

	Timothy hay	Rolled barley	Soy protein
Dry matter (%)	89.4	87.8	89.1
Crude protein (%)	8.4	11.2	85.1
Crude fat (%)	2.3	1.4	0
Crude fibre (%)	26.6	1.3	0
NFE <sup>1)</sup> (%)	42.8	71.3	0
Crude ash (%)	9.3	2.6	4.3
TDN <sup>2)</sup> (%)	62.1	86.4	85.0

<sup>1)</sup> Nitrogen free extract. <sup>2)</sup> Total digestible nutrients.

**Fig. 1** The growth curves of lambs during the period.

mineralized salt lick at all time. The animals were weighed once a week before the morning feed. The feed intake (roughage & concentrate separately), feed residue (orts), faeces and urine were volumetrically measured, and kept on record daily during entire experimental period.

#### Experimental procedure

On the 1-, 2- and 3-weeks after weaning, and also 2-, 3- and 5-month-old of lambs, daily feed intake, and feed residue were measured during 5-7 days, and also collected faeces and urine for checking digestibility of the diet and N balance.

The nitrogen (N) in the diet, orts, faeces and urine was analyzed by the Kjeldahl method, and the contents of crude fat, crude fibre and ash in the diet were determined according to AOAC (Association of Official Analytical Chemists) method<sup>7)</sup>. The urinary N was analyzed daily in each animal, and the values were averaged in each period. The N in the orts and faeces was measured using the mixed samples of each period.

## **Results and Discussion**

#### Feed intake and growth rate

In Figure 1, the changes in body weight of lambs after weaning are shown, and there were clearly some difference in growth rate between two groups of dietary protein level. On the first week after weaning, there was no difference in body weight of twin lambs; there were clear difference of body weight in HP group and LP group at 5 month after birth as follows; nos. 4 & 5: 5 kg, nos. 9 & 10: 12 kg, *i. e.*, high protein diet surely increased the body weight. This result clearly confirmed that in animals reared with high

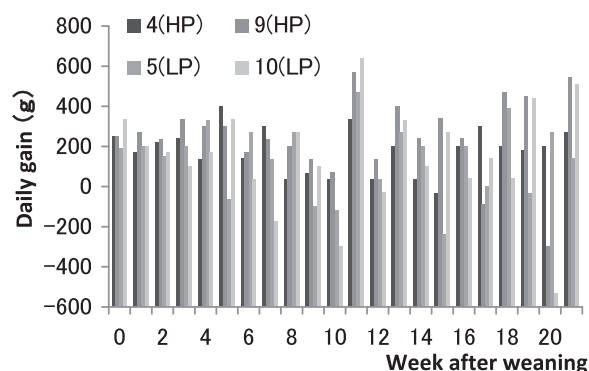


Fig. 2 The dairy gain of lambs during the period.

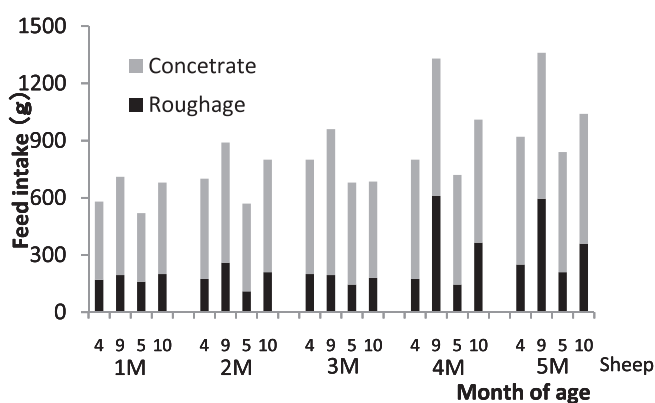


Fig. 3 The feed intake in lambs during the period.

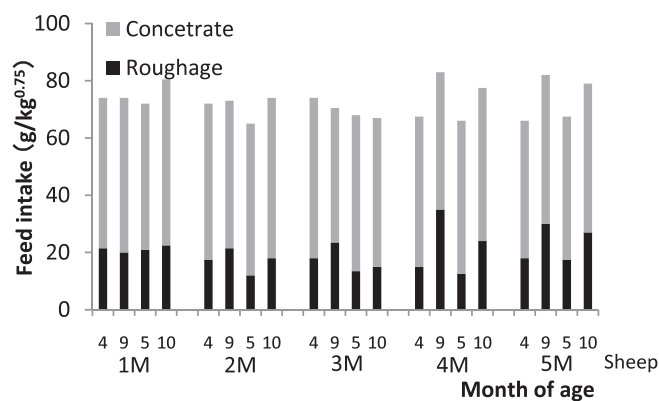


Fig. 4 The feed intake per metabolic body weight in lambs during the period.

concentrate diet, *i. e.*, high nutritional level feeding, obviously increases the rate of growth<sup>8,9)</sup>.

As shown in Figure 2, the average daily gain (ADG) in every week after weaning was 153, 142, 235 and 145 g in No. 4, No. 5, No. 9 and No. 10 lambs, respectively. The difference in ADG between HP and LP groups were higher in crossbred lambs than in Japanese Corriedale lambs, and it would be caused by the difference of type of breed, *i. e.*, meat type (nos. 9 & 10) and wool type (nos. 4 & 5). The average daily gain in Japanese Corriedale twin was relatively steady as compared with that in another twin along with the growth, and in particular the value in No. 9 lamb was fairly high rather than the other after 11<sup>th</sup> week. The ADG of No. 10 lamb was relatively big variance through the entire experimental period as compared with that in other lambs. The change in DG of No. 9 lambs during 9<sup>th</sup> to 15<sup>th</sup> weeks was greater than those in other lambs, and it would be due to decrease of roughage intake in animals except No. 9 during summer

season. Then, monthly feed intake in individual, and also that per metabolic body weight (MBW) during the entire experiment were shown in Figures 3 and 4, and so, feed intake of No. 9 lambs was superior to those of other lambs. This period was almost the same to the periods of 9<sup>th</sup> to 15<sup>th</sup> weeks of experiment. The quite big difference in roughage intake between No. 9 and other lambs could cause to difference in DG. In general, there will be a close relationship between a development of the reticulo-rumen and an increase of DG in young ruminants. Brownlee<sup>10)</sup> and Warner *et al.*<sup>11)</sup> have shown that a development of the rumen could be clearly influenced with chemical property of solid feed ingested, and feeding of a high energy concentrate-diet has an effect on the development of mucosal papilla in the rumen. Tamate *et al.*<sup>4)</sup> has also reported a physical property of roughages ingested obviously contribute to increase of volume in reticulo-rumen and development of muscle layer of rumen wall. Furthermore, Harisson *et al.*<sup>12)</sup> and Stobo *et al.*<sup>13)</sup> have demonstrated that the change in a quality of solid feed (such as a ratio of roughage and concentrate) has been adapted to a morphological change of the reticulo-rumen. As

**Table 2.** The average body weight and feed intake in lambs during the period

	Period after weaning					
	1	2	3 <sup>1)</sup>	2	3	5 <sup>2)</sup>
Body weight (kg)						
No. 4 <sup>3)</sup>	12.5	13.8	15.2	21.0	23.8	33.0
No. 5 <sup>4)</sup>	11.7	12.6	13.8	17.8	21.2	28.2
No. 9 <sup>3)</sup>	16.6	18.0	20.0	27.2	31.8	42.8
No. 10 <sup>4)</sup>	13.8	15.8	17.0	23.6	26.2	30.8
Feed/nutrient intake (g/d/h)						
Timothy hay						
No. 4	167	179	162	214	283	418
No. 5	150	166	163	155	181	330
No. 9	174	201	243	300	700	694
No. 10	177	247	249	242	433	433
Concentrate <sup>5)</sup>						
No. 4	396	396	452	676	676	746
No. 5	388	388	388	528	668	708
No. 9	536	536	571	716	816	886
No. 10	528	528	528	668	708	758
Dry matter (g/d/h)						
No. 4	500	510	528	788	843	1022
No. 5	477	492	489	606	753	922
No. 9	625	648	716	894	1329	1365
No. 10	616	688	690	808	1014	1058
Crude protein (g/d/h)						
No. 4	189	190	196	227	233	250
No. 5	124	126	125	134	141	153
No. 9	213	215	221	241	278	273
No. 10	136	142	142	146	162	163

<sup>1)</sup> Week. <sup>2)</sup> month. <sup>3)</sup> Lamb No. in HP group. <sup>4)</sup> Lamb No. in LP group.

<sup>5)</sup> Rolled barley + soy protein.

mentioned above, there is a close relationship between a solid feed intake and growth rate, *i. e.*, daily gain in ruminant animal. In the Tables 2 and 3, the ADG, feed intake, digestibility of dry matter (DM) and crude protein (CP), and total digestible nutrients (TDN) intake in each twin lambs within the experimental period are shown. As described above, it was very hot summer in the year when the experiment has been done, and so experimental animals resulted in to be exposed to the hot environment for a quite long period. Ruminant animals will be generally thought to be not strong under a hot environment, and so a decline of feed intake leading a lower growth rate after weaning is relatively common under those conditions. In the present study, as described before, roughage intake of lambs except No. 9 were influenced under the hot environment, but the intake of concentrate increased along with an increase of body weight individually. As a result, therefore, the total intakes of CP and TDN in all the animals might be imagined to be increased totally in the present study. In the present experiment, all the animals had completely consumed the concentrate offered during the period, *i. e.*, their protein intake increased along with the stage of growing, and consequently, averaged CP intake in HP group was 1.6 times higher than that in LP group. On the TDN intake during the period, there was no difference between two groups at one week after weaning; however, on the 5 month after weaning, the total intake in HP group (100 & 250 g/d: nos. 4 & 9) was greater than that in LP group (nos. 5 & 10). The DM digestibility in nos. 4 & 5 increased until 3 month after weaning and at 5 month it decreased, and that in nos. 9 & 10 increased only until 3 weeks after weaning and thereafter it decreased until the end of the experiment. The difference of DM digestibility between 2 groups (within twins) would be due to an increase of roughage intake in HP group during the period, in particular in No. 9 lamb, the continuous increase of roughage intake resulted in a relatively low DM digestibility during the period. There was a little difference in DM digestibility between 2 animals of each twin. As described above, a development of reticulo-rumen stimulated through an increase of feed intake could be thought to increase in body weight in lambs.

**Table 3.** Digestibility of dry matter and crude protein and TDN<sup>1)</sup> intake in lambs

	Period after weaning					
	1	2	3 <sup>2)</sup>	2	3	5 <sup>3)</sup>
Dry matter (%)						
No. 4 <sup>4)</sup>	75.6	77.5	76.6	79.0	78.6	74.8
No. 5 <sup>5)</sup>	76.0	74.9	78.7	75.7	79.5	72.6
No. 9 <sup>4)</sup>	78.8	78.9	82.2	81.1	73.6	71.7
No. 10 <sup>5)</sup>	75.9	76.6	79.7	77.5	73.9	69.3
Crude protein (%)						
No. 4	88.7	89.1	88.5	86.8	87.4	85.3
No. 5	84.9	82.6	86.0	81.4	81.9	78.4
No. 9	87.9	86.9	88.7	87.3	82.0	76.2
No. 10	80.5	82.4	82.4	78.6	78.0	72.5
TDN intake (g/d/h)						
No. 4	362.5	379.2	401.3	600.1	642.2	740.0
No. 5	348.5	353.6	369.5	441.6	577.1	641.5
No. 9	477.2	495.6	570.0	701.7	945.0	947.2
No. 10	456.3	505.6	527.0	601.2	715.7	701.5

<sup>1)</sup> Total digestible nutrients. <sup>2)</sup> Week. <sup>3)</sup> Month. <sup>4)</sup> Lamb No. in HP group.

<sup>5)</sup> Lamb No. in LP group.

**Table 4.** Nitrogen balance in lambs fed on LP or HP diet.

	Period after weaning					
	1	2	3 <sup>1)</sup>	2	3	5 <sup>2)</sup>
Intake (g/d/h)						
No. 4 <sup>3)</sup>	30.2	30.3	31.4	36.3	37.3	40.0
No. 5 <sup>4)</sup>	19.9	20.1	20.0	21.5	22.6	24.5
No. 9 <sup>3)</sup>	34.0	34.4	35.5	38.6	44.5	43.6
No. 10 <sup>4)</sup>	21.5	22.7	22.7	23.4	25.9	25.5
Fecal N (g/d/h)						
No. 4	3.36	3.30	3.56	4.84	4.71	5.93
No. 5	3.00	3.48	2.77	4.04	4.15	5.26
No. 9	4.15	4.52	4.04	4.89	8.00	10.40
No. 10	4.23	4.03	4.03	5.02	5.73	7.05
Urinary N (g/d/h)						
No. 4	3.18	2.74	5.58	4.55	6.63	6.16
No. 5	2.33	2.21	2.59	4.04	5.03	5.86
No. 9	5.86	6.00	4.52	7.31	10.33	5.01
No. 10	2.38	2.48	2.05	3.06	5.49	3.71
Retained N (g/d/h)						
No. 4	23.6	24.3	22.2	27.0	26.0	27.9
No. 5	14.6	14.4	14.6	13.5	13.5	13.4
No. 9	24.0	23.9	27.0	26.4	26.2	28.2
No. 10	14.6	16.2	16.7	15.3	14.7	14.7
Retain N/Ingested N (%)						
No. 4	78.1	80.2	70.7	74.4	69.7	69.8
No. 5	73.4	71.6	73.0	62.8	59.7	54.7
No. 9	70.6	69.5	76.1	68.4	58.9	64.7
No. 10	69.3	71.4	73.6	65.4	56.8	57.6
Retained N/absorbed N (%)						
No. 4	88.1	90.0	79.9	85.6	79.7	81.8
No. 5	86.5	86.7	84.9	77.1	72.9	69.8
No. 9	80.3	80.0	85.8	78.4	71.8	84.9
No. 10	86.1	86.7	89.3	83.2	72.8	79.5

<sup>1)</sup> Week. <sup>2)</sup> Month. <sup>3)</sup> Lamb No. in HP group. <sup>4)</sup> Lamb No. in LP group.

#### The changes in N balance during growth

The change in N balance of each lamb during the experimental period is shown in the Table 4, and the N balance of individual at 1, 2 and 3 weeks and at 1, 2, 3, and 5 months after weaning are shown in Figures 5 and 6, respectively.

The N intake obviously increased along with increase of body weight, and the value was greater in HP group than in LP group. The ratio of N absorption (Absorbed N/consumed N) and the ratio of N retention (retained N/consumed N) were also higher in HP group than in LP group. In the LP group (Figure 5), at 3 weeks after weaning averaged N intake was 30 g/d and 20 g/d in No. 4 and No. 5 lambs, respectively, and N excretion into faeces were almost the same in all animals regardless individual N intake. In urinary N excretion, there were a little change at 1 and 2 weeks after weaning, and then, at 3

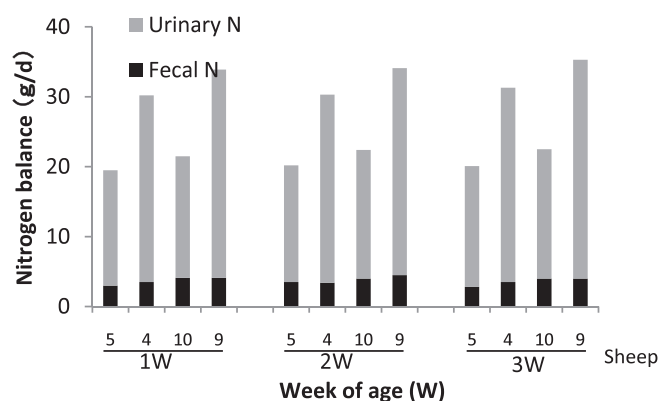


Fig. 5 Nitrogen balance of lambs during 3 weeks after weaning.

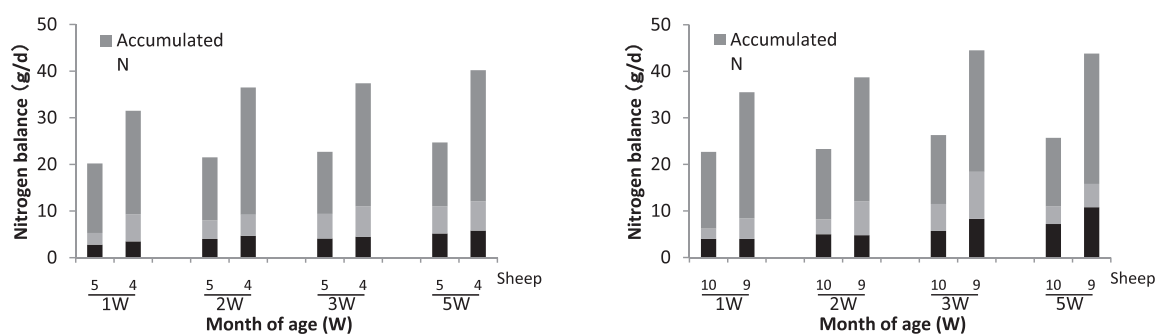


Fig. 6 Nitrogen balance of lambs during 5 months after weaning.

weeks after weaning, the urinary N excretion of No. 4 lamb (5.58 g/d) was about 2 times higher than that of No. 5 Lamb (2.59 g/d). Consequently, in No. 4 lamb the N intake did not clearly change during 3 weeks after weaning, and so retained N also decreased leading a lower N utilization (retained N/absorbed N). The ratio of N absorption in LP group after weaning did not change during 3 weeks, and the figures were higher in No. 4 lamb than in No. 5 lamb. In the ratio of N retained, the value declined at 3 weeks after weaning in No. 4 lamb. The N utilization (retained N/absorbed N) was always higher in No. 4 lamb than in No. 5 lamb during the period except the value at 3 weeks after weaning. In the HP group, there was no change in N intake of twin lambs (No. 9: 34 g/d, No. 10: 22 g/d) during 3 weeks after weaning, and the value of No. 9 lamb was 1.6 times higher than that in No. 10 lamb. The faecal N output was almost the same in both lambs, and the values are almost constant during the period. Urinary N excretion, however, in No. 9 lamb was always (in every weeks) more than 2 times higher than that in No. 10 lamb. The ratio of N absorption did not change in both lambs during 3 weeks after weaning, and the value was higher in No. 9 lamb than in No. 10 lamb. The ratio of retained N was almost steady during 3 weeks except value of No. 9 lamb at 3 week after weaning. The N utilization was different between 2 twins, and the value in No. 10 lamb was higher than that in No. 9 lamb, and also the averaged values were the opposite in two groups. In No. 9 lamb, high N intake, high urinary N excretion and also high N retention were observed, however the ratio of N utilization was lower than that in No. 10 lamb. The urea N (NPN) synthesized in the body will be thought to be an end product of protein and/or amino acids metabolism, and excreted through the kidney. In adult ruminants, it is well recognized that when they received high protein feed the urinary excretion of urea markedly increase, and contrary when they were fed a low protein feed, they will be able to control the urinary urea excretion, and shift to secrete urea into the gut (reticulo-rumen) for stimulating the microbial protein synthesis<sup>14)</sup>. Obara *et al.*<sup>15)</sup> reported that the rumen will be a main place for using an endogenous urea in ruminants fed low protein diet, and also when the diet contains enough



nitrogen to be absorbed an endogenous urea will be secreted into the lower gut. Then, in the present study, nitrogen intake increased through high protein diet in No. 9 lamb, and a provided large amount of protein would be too much for protein utilization in the body, and so excess nitrogen might be used for urea synthesis to be excreted into urine.

As shown in the Figure 6, in the monthly changes in N balance after weaning in nos. 4 and 5 lambs, monthly N intakes of No. 4 and 5 were increased 1.3 and 1.2 times during 5 months. The faecal N excretion also increased along with the lapse of time after weaning, though there was little difference in individuals. Urinary N excretion in No. 4 lamb was 2 times more than that in No. 5 lamb at one month after weaning, and thereafter, the extent of increase in urinary N in 2 lambs was almost the same during the period. The retained N at 5 month in No. 4 lamb increased 1.3 times as compared to that at one month after weaning, although in No. 5 lamb, the N retention decreased slightly during the period. As shown in Figure 2, the DG in No. 4 lamb during experimental period was 233, 300, 33 and 267 g/d at 1, 2, 3 and 5 month after weaning, and also that in No. 5 lambs was also 200, 133, 33 and 133 g/d at 1, 2, 3, and 5 month after weaning, respectively. The N retention at the same time described above increased almost the same rate in No. 4 and 5 lambs, and so an increase in N retention was roughly reflected on an increase in DG, *i. e.*, an increase of protein synthesis in the body. In the nos. 4 and 5 lambs, absorbed N increased along with growing stage, though N retention in No. 5 lamb decreased slightly. In the nos. 9 and 10 lambs, N intake in No. 9 lamb was high as compared to other, and it would be due to more in concentrate intake as compared with that in No. 10 lamb. The N intake in nos. 9 and 10 lambs increased until 3 month after weaning, and then it tended to be relayed at 5 month after weaning. The faecal N excretion increased along with the lapse of time after weaning in both lambs, although there was a difference individually, and then, it tended to increase in No. 9 lamb at 3 month after weaning. This could be due to no reflection of an increase in feed intake to digestion and absorption of dietary nitrogen. The urinary N excretion increased in both lambs along with the lapse of time, and the value in No. 9 lamb was almost 2 times higher than that in No. 10 lamb until 3 month after weaning, and then the values in both lambs decreased in similar extent at 5 month after weaning. In the both lambs of nos. 9 and 10, their body weight increased, although the N intake of them was relatively delayed at 5 month after weaning. At 5 month after weaning, it can be presumed that their protein synthesis in the body was great resulted in control urinary urea excretion, and consequently, the urinary N excretion decreased in nos. 9 and 10 lambs. Nitrogen retention in No. 9 lamb increased as 27.0, 26.4, 28.2 (g/d), and that in No. 10 lamb relatively decreased as 16.7, 15.3, 14.7 and 14.7 (g/d) at 1, 2, 3 and 5 month after weaning, respectively. The DG in No. 9 lamb during same period were 333, 200, 333 and 533 (g/d), and it was in proportion to an increase in N retention.

In both groups of HP and LP, an absorbed N increased along with an increase in N intake due to increase in body weight through aging of lambs. However, in this study, N retention in HP group increased along with aging, although there was a little decline in LP group. Therefore, it is thought to that the difference in dietary protein level will influence to N retention, and then it should have some effect on the growth rate in growing lambs. The N intake in lamb was relatively higher in HP group than in LP group, and subsequently, there were also high absorbed and retained N in HP group as compared to that in LP group. However, as shown in Table 4, the differences in dietary protein level clearly influenced on the absorption and retention rates of N in lambs. That is, the absorption and retention rates were significantly higher in HP group than in LP group. The rates of absorption and retention of nitrogen decreased along with aging of lambs after weaning in both groups. In particular, it was thought to that N absorption was high and also protein synthesis has been done actively in No. 9 lamb. On the other hand, urinary N excretion was also high, and consequently the retained N increased but N utilization was not

always improved in No. 9 lamb. In nos. 5 and 10 lambs, N utilization rate was not always lower, although their absorbed N was relatively not so much. Then, the difference in dietary protein level is thought to have no big effect on N utilizability in lambs. One side, the N utilizability in lambs was relatively high until 3 weeks after weaning, and thereafter it tended to decrease.

For comparison the result of individuals, the changes in N balance (per  $BW^{0.75}$ ) of lambs until 3 weeks after weaning were shown in Table 5, and that in 1, 2, 3 and 5 months after weaning were also shown in Table 6, respectively. The N retention in No. 4 and 5 lambs was 3.6, 2.2 and 2.9, and 2.3, 2.2 and 2.0 at 1, 2 and 3 weeks after weaning, respectively. Therefore, the retained N per  $kgBW^{0.75}$  decreased along with aging, and then the value tended to high in HP group than in LP group. In the twin of No. 9 and 10, there

**Table 5.** Nitrogen balance indicated as per metabolic body weight in lambs fed on LP or HP diet

Lamb No.		5	4	10	9
1 <sup>st</sup> week <sup>1)</sup>	Fecal	0.46 <sup>2)</sup>	0.50	0.58	0.49
	Urinary	0.34	0.49	0.34	0.70
	Retained	2.26	3.46	2.06	2.86
2 <sup>nd</sup> week	Fecal	0.52	0.46	0.50	0.53
	Urinary	0.33	0.39	0.31	0.68
	Retained	2.12	3.32	2.06	2.46
3 <sup>rd</sup> week	Fecal	0.38	0.46	0.48	0.43
	Urinary	0.35	0.72	0.24	0.44
	Retained	2.08	2.88	1.96	2.90

<sup>1)</sup> After weaning. <sup>2)</sup> g/kgBW<sup>0.75</sup>

**Table 6.** Nitrogen balance indicated as per metabolic body weight in lambs fed on LP or HP diet

Lamb No.		5	4	10	9
1 <sup>st</sup> month <sup>1)</sup>	Fecal	0.40 <sup>2)</sup>	0.46	0.48	0.45
	Urinary	0.36	0.72	0.24	0.44
	Retained	2.08	2.92	1.96	2.92
2 <sup>nd</sup> month	Fecal	0.47	0.50	0.48	0.41
	Urinary	0.47	0.46	0.28	0.60
	Retained	1.54	2.72	1.46	2.14
3 <sup>rd</sup> month	Fecal	0.40	0.44	0.50	0.60
	Urinary	0.51	0.57	0.47	0.76
	Retained	1.36	2.48	1.24	1.92
5 <sup>th</sup> month	Fecal	0.43	0.44	0.55	0.64
	Urinary	0.47	0.46	0.27	0.30
	Retained	1.10	2.04	1.18	1.68

<sup>1)</sup> After weaning. <sup>2)</sup> g/kgBW<sup>0.75</sup>

was a similar trend in N retention until 3 weeks after weaning that observed in the twin of No. 4 and 5. It is thought to be that an increase in the retained N per  $BW^{0.75}$  might induce the N utilization for body protein synthesis per  $BW^{0.75}$ , which would improve growth rate of lamb. In the DG during 3 weeks after weaning, it reflected on the retained N per  $BW^{0.75}$  in both twins of nos. 4 and 5, and 9 and 10 lambs. Furthermore, on the changes in N balance during 5 months after weaning, the retained N per  $BW^{0.75}$  tended to decrease along with aging in both groups, and in particular the values of No. 9 lamb varied more than those of other lambs. The retained N per  $BW^{0.75}$  during the whole period of this study was quite more until 3 weeks after weaning in all the animals, although that increased along with aging. On the other hand, the changes in dietary protein level might induce the retained N per  $BW^{0.75}$  relating the changes in protein synthesized in the body.

### Conclusion

In the present study, it was obviously suggested that the change in the DG of lamb in growing stage is obviously influenced by a changes in retained N caused by a changes in dietary protein level. In the lamb fed on high protein diet, the ratio of absorption and retention of N tended to high as compared with that in lambs fed on low protein diet. Further, N retention per  $BW^{0.75}$  tended to decrease along with aging, although it will be more in the early stage after weaning.

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## 育成メノウの増体および窒素出納に及ぼす 給与飼料中蛋白含量の影響

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### 要 旨

反芻動物の成長に伴う反芻胃の発達や単胃動物型から反芻（複胃）動物型への栄養摂取形態の変化が蛋白質栄養に及ぼす影響については未だ十分に明らかではない。本研究では、離乳後の育成メノウに蛋白質レベルの異なる飼料を給与し、増体および窒素出納に及ぼす影響について比較検討した。

生後 55 日齢で離乳した 2 組の双子（雌）メノウを供試し、各双子内で高タンパク飼料区（HP 区）と低タンパク飼料区（LP 区）に振り分けた。市販のチモシー乾草を基礎飼料とし、圧ぺん大麦と大豆たんぱくを用いて、蛋白含量を HP 区で維持要求量の 1.8 倍、LP 区は 1.2 倍になるよう調整した。各個体の採食量は毎日、体重は週齢ごとに測定した。また、離乳後 1, 2 および 3 週齢と 2, 3 および 5 カ月齢の 6 期間を試験期として、各期間中の残飼量、糞および尿を毎日採取し、それらの窒素（N）量を測定して N 出納を算定した。全実験期間中の平均日増体量は、日本コリデール種の双子において、HP 区で 153 g, LP 区で 142 g であり、交雑種（日本コリデール種 X サフォーク種）の双子において、HP 区で 235 g, LP 区で 145 g であった。飼料摂取量については、濃厚飼料は各個体ともほぼ全量を摂取したが、粗飼料は交雑種の HP 区以外は、夏季の暑熱環境下で摂取量が一時減少した。HP 区における N 摂取量は LP 区におけるそれよりも多く、結果としての体内蓄積 N 量も HP 区で LP 区よりも多くなった。また、週齢に伴い N 摂取量は増加したが、排泄 N 量も増加したことから、体内蓄積 N 量の割合は低下した。週齢に伴う体内蓄積 N 量は HP 区では増加したが、LP 区ではやや減少する傾向にあった。代謝体重当たりの体内蓄積 N 量は、各双子の LP 区で変化は認められなかったが、HP 区では離乳後 2 カ月以降における交雑種（nos. 9 & 10）の減少が顕著であった。

これらの結果は、育成時のヒツジにおける日増体量の変化が、給与飼料中のタンパクレベルの変化に起因する蓄積窒素量の差によって明らかに影響されることを示唆している。