Effect of Parotid Saliva Secretion on Dry Forage Intake in Goats

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ABSTRACT : Research was carried out to clarify whether a suppression of dry forage intake during the early stages of feeding in ruminants is caused by feeding induced hypovolemia which is produced by the accelerated secretion of parotid saliva. Goats with a parotid fistula were fed roughly crushed alfalfa hay cubes, commercial ground concentrate feed and $NaHCO_3$ twice daily (10:00-12:00, 16:00-18:00). The animals were free access to drinking water all day prior to, during and after experiments. The animals were intraruminally infused every day prior to the morning feeding period with parotid saliva collected from the parotid fistula over a 24 h period. The present experiment consisted of two treatments, non-infusion (RNI) and intraruminal infusion of parotid saliva (RSF). In the RSF treatment, 4-5 kg of parotid saliva (280-290 mOsm/l) collected over a 24 h period was intraruminally infused 1 h prior to the commencement of the morning feeding. During feeding, eating and parotid saliva secretion rates were measured. Blood samples were also periodically collected from the jugular vein. During and after 2 h feeding, water intakes were measured, respectively. These measurements were used to define thirst levels. It is thought that rumen fill in the RSF treatment was higher than the RNI treatment. Plasma osmolality in the RSF treatment increased in the first half of the 2 h feeding period due to the intraruminal infusion of parotid saliva. Therefore, parotid saliva secretion rates in the RSF treatment were lower than the RNI treatment for 30 min period from 30 to 60 min after the commencement of feeding. On the other hand, plasma total protein concentration and hematocrit in the RSF treatment decreased by 3.2 and 3.3% prior to the commencement of feeding due to the intraruminal infusion of parotid saliva. In the first half of the 2 h feeding period, plasma total protein concentration and hematocrit in the RSF treatment showed a tendency to decrease compared to the RNI treatment. Thirst level in the RSF treatment during feeding was approximately 31.3% less than the RNI treatment. Upon the completion of the 2 h feeding period, cumulative feed intake in the RSF treatment was significantly larger (19.7%) than the RNI treatment. The results suggest that a suppression of dry forage intake during the early stages of feeding in goats is partly caused by feeding induced hypovolemia, which is produced by the accelerated secretion of parotid saliva. ***(Asian-Aust. J. Anim. Sci. 2003. Vol 16, No. 8 : 1118-1125)***

Key Words : Parotid Saliva Secretion, Thirst Sensation, Dry Forage Intake, Goats

INTRODUCTION

Ruminants consume an enormous amount of hay (lower energy content) in a short time. Saliva in sheep is secreted in large volumes during the first hour after the commencement of dry forage intake (Sato, 1975). Saliva acts as a lubricant in the mouth and esophagus, and assists in the mastication, re-mastication, swallowing and re-swallowing of dry forage. Saliva also acts as an alkaline and serves to buffer the decrease in the pH of rumen fluid due to the volatile fatty acid production of microbial fermentation in the rumen. In this way, saliva plays an important role in eating and homeostatic regulation of the acid-base balance in rumen fluid.

Daily saliva secretion volumes were 6 to 16 L in sheep (Kay, 1960), and 98 to 190 L in cattle (Bailey, 1961). The bilateral glands contributing to the total saliva secretion volumes are the parotid, submandibular, inferior molar, sublingual, buccal, labial, pharyngeal and palatine glands (Carter and Grovum, 1990). Parotid saliva secretion contributes 50 to 60% of the total saliva secretion volumes. Parotid saliva is considered to be the fluid supply for the non-secretory rumino-reticulum (Kay, 1966). Secretion rates of parotid saliva in goats fed alfalfa hay cubes twice a day peaked immediately following the start of feeding, but decreased sharply 30 min following the start of feeding (Sunagawa et al., 2002b). Eating rates in goats fed alfalfa hay cubes also rapidly decreased in the first 40 min of feeding. Sunagawa et al. (2002b) reported that intraruminal infusion of parotid saliva increased dry forage intake in goats deprived of water during feeding. From these reports, it is thought that parotid saliva secretion volume is a regulating factor in dry forage intake. Until now, experiments investigating the physiological relationship between parotid saliva secretion volume and dry forage intake have not been conducted.

In the present experiment, the animals were prepared with a parotid fistula. Parotid saliva from the fistula was collected and infused into the rumen once each day prior to morning feeding. The present experiment was conducted to clarify whether a rapid decrease in eating rates with feeding is partly caused by decrease in secretion rates of parotid saliva in goats with free access to water.

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MATERIALS AND METHODS

Animals

Five goats (1 Japanese Saanen goat, aged 4 yr, weighing 72.5 kg; 4 crossbred Japanese Saanen/Nubian goats, aged 3-5 yr, weighing 72, 83, 90, 97 kg) were used in this experiment. In order to collect parotid saliva, the apertura of one of the parotid ducts was surgically prepared to exteriorize it via the cheek of the animal more than 6 month prior to experimentation. Either an Atom Disposable Multiple Purposes Tube (o.d. 2.75 mm, 8 Fr, Atom, Tokyo) approximately 10 cm in length or depending on the animal, a fluid infusion tube (o.d. 4.00 mm, Terumo, Tokyo) was inserted into the parotid duct and fixed to the cheek. Furthermore, to enable the return of saliva collected from the parotid fistula, an extension tube (X3-25, Top, Tokyo) was inserted into the dorsal sac of the rumen. The other end of the tube was fixed to the skin. Parotid saliva flowing from the parotid fistula was collected in a plastic bucket. The sheep were maintained in metabolism cages that allowed for the separate collection of urine, feces and saliva.

The animals were fed twice a day at 10:00 am and again at 4:00 pm for 2 h each time. Prior to the morning feeding, the collected saliva (3-5 kg) was infused into the rumen via the extension tube using a bathtub pump (Minipandy, KP-30F, Koshin, Tokyo). Following this, 2-3 kg of roughly crushed alfalfa hay cubes, 20 g of $NaHCO_3$ and 200 g of commercial ground concentrate feed were fed to the animals for 2 h.

Animals were given free access to water throughout the day. The alfalfa hay cubes (83.4% dry matter) contained, on a dry matter basis, 18.7% crude protein, 2.4% crude fat, 29.7% crude fiber, 39.7% nitrogen free extracts (NFE), 45.9% neutral detergent fiber (NDF) and 36.6% acid detergent fiber (ADF). The proportion of each ingredient in the ground concentrate feed was 48% maize, 24% sorghum, 1% barley, 5.0% rice polishing, 0.5% sodium chloride, 0.05% dicalcium phosphate and 0.05% vitamin-trace minerals premix. The concentrate feed (86.9% dry matter) contained, on a dry matter basis, 13.4% crude protein, 3.6% crude fat, 3.7% crude fiber, 71% NFE, 14.6% NDF and 5.4% ADF. Alfalfa hay cubes were ground with a willey mill (Type 40-525P, Ikemoto Rika Kougyou, Tokyo, Japan). The chemical components of their feeds were quantified using the procedures described by Nihon Shiryo Kyoukai (Kato, 1988).

Experiment

The experiment was carried out in a laboratory with a room temperature of 24-26°C and a relative humidity of 74-84%. Before morning feeding, parotid saliva was infused intraruminally to clarify whether a marked decrease in parotid saliva secretion during the early stages of feeding depresses feed intake in goats with free access to water. The control treatment monitored cumulative feed intake and eating rates in the absence of infusion. Treatments in this experiment were carried out in order, beginning with the no infusion control (RNI) followed by the parotid saliva intraruminal infusion treatment (RSF). The goats used in this experiment had free access to water during feeding. The treatments were carried out on 2-3 animals at one-week intervals to ensure that animals recovered and to minimize the compounding effects of the previous treatments. Respiration frequency, heart rate and rectal temperature were measured every day prior to the morning feeding period. The values of these physiological parameters indicated whether an individual was in good health and had no measurable carry-over effects from the previous treatments. In order to take blood samples during the course of the experiment, a polyethylene tube (o.d. 1.5 mm, No. 5, Imamura Gomu, Tokyo) was inserted into the jugular vein of the animals on the day prior to the commencement of experimentation. This tube was fixed in place and filled with heparine-saline solution (50 i.u./ml) to prevent coagulation of the blood. On the day of the experiment, depending on the animal, either an extension tube (o.d. 2.0 mm, X-1, Top, Tokyo) or a polyethylene tube (o.d. 2.2 mm, No. 7, Imamura Gomu, Tokyo) was connected to the tube inserted into the parotid fistula. From the open end of the tube, parotid saliva was collected in a graduated measuring cylinder (100 ml). On the day of the RSF treatment, 4.0-5.0 kg of saliva was infused into the rumen using a bath tub pump (Minipondy, KP-30F, Koshinsha) 1 h prior to the commencement of the morning feeding period. The infusion volume for animals weighing 72.5, 83.0, 90.0 and 97.0 kg was 5.0 kg, while the animal weighing 72.0 kg was infused with 4.0 kg. Feeding was begun at 10:30 am and the animals were fed roughly crushed alfalfa hay cubes for 2 h. Eating rates were determined using a measuring scale. The alfalfa hay cubes (2.0-3.0 kg) were placed in a feed box attached to a 6 kg measuring scale. The weight of the remaining feed was measured every 10 min for the duration of the 2 h feeding period. The rate of saliva secretion was measured in a graduated cylinder. Measurements began 10 min prior to feeding commencement and continued every 10 min for the duration of the feeding period and concluded with the last measurement being taken at the end of the 2 h feeding period. To measure the osmolality of saliva, a sample of the collected parotid saliva was taken. This sample was placed in a test tube and refrigerated until measuring. Water intake was measured at the end of the 2 h feeding period and again 30 min following the completion of the feeding period. Fluid intake is regulated by the thirst mechanisms (Guyton and Hall, 1996, Prasetiyono et al., 2000). In the present experiment, the level of thirst (water appetite) was evaluated quantitatively using water intake.

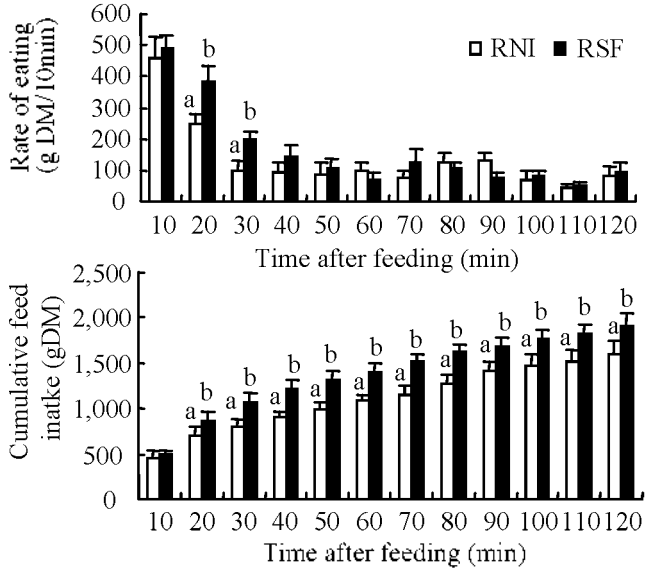

Figure 1. The effect of intraruminal infusion of parotid saliva (RSF) on rate of eating and cumulative feed intake in goats with free access to water. Values are mean±S.E. (n=5) of five goats. [a, b] Means with different superscripts are significantly different from no infusion treatment (RNI, $p<0.05$).

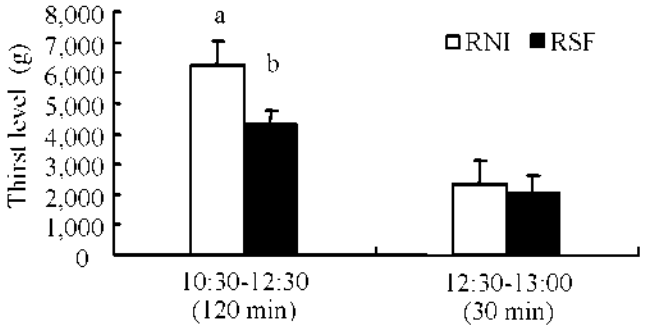

Figure 2. The effect of intraruminal infusion of parotid saliva (RSF) on thirst levels during and after feeding in goats with free access to water. Values are means±S.E. (n=5) of five goats. [a, b] Means with different superscripts are significantly different from no infusion treatment (RNI, $p<0.05$).

A total of 10 blood samples were taken, 2 each prior to and after the feeding period, and 6 during feeding after 10, 30, 45, 60, 90, 120 min had elapsed. Blood samples (5 ml each) were taken from the jugular vein. Samples were collected in heparinized tubes to prevent coagulation and were subsequently refrigerated. Blood plasma was obtained by centrifugation (16,260×g, 10 min, 5°C).

Biochemical analysis

Alfalfa hay cubes were ground with a Willey mill (Type 40-525 P, Ikemoto Rika Kougyou, Tokyo, Japan). The chemical components of their feeds were quantified using the procedures described by Nihon Shiryo Kyoukai (Kato, 1988).

Saliva osmolality was measured according to the principle of freezing-point method using an osmometer (Model OM-6010, Kyoto Daiichi Kagaku, Kyoto). Blood samples were placed in hematocrit capillary tubes and centrifuged using a hematocrit centrifuge (HC-12 A, Tomy Seiko, Tokyo, 16,260×g×5 min) to separate plasma and red blood corpuscle. A hematocrit reader determined hematocrit. Plasma protein and osmolality were measured by a refractometer (Atago, Tokyo) and by an osmometer, respectively. Plasma Na, K and Cl were measured with Spotchem EL (SE-1520, Arklay, Kyoto).

Statistical analysis

The experiments in this research were conducted according to a switchback design. A two-way analysis (animal, treatment) of variance was performed. Following that an F-test was used to compare the treatments. For statistical analysis, GLM procedures (SAS, 1990) were adopted. Data are presented as means±SE (n=5) of five sheep.

RESULTS

Physiological responses

The mean values of respiration frequency, heart rate and rectal temperature before infusion in the two treatments were 31±2.9 breaths/min, 83±3.0 beats/min and 38.9±0.04°C, respectively.

The rate of eating and cumulative feed intake

The rate of eating and cumulative feed intake is shown in Figure 1. Eating rates in the RNI treatment rapidly decreased in the first 40 min of the feeding period (0 to 10 min 455 g/10 min, 30 to 40 min 101 g/10 min). However, eating rates in the RSF treatment decreased slowly until 60 min of the feeding period had elapsed. Eating rates in the RSF treatment during the first 60 min of feeding were higher than those in the RNI treatment. After 60 min of the feeding period had elapsed, there were no significant differences between two treatments.

The cumulative feed intake of both treatments upon the conclusion of the 2 h feeding period was RNI: 1,597±137.7 g/2h and RSF: 1,912±131.6 g/2h. Compared with the RNI treatment, cumulative feed intake in the RSF treatment was 19.7% larger upon conclusion of the 2 h feeding period.

Thirst level

The thirst levels calculated using the water intake of the 2 h feeding period and the water intake of the 30 min period following the conclusion of feeding are shown in Figure 2. Thirst levels during feeding were RNI: 5,230±1,188 g/2h, RSF: 4,150±1,190 g/2h. Compared to the RNI treatment,

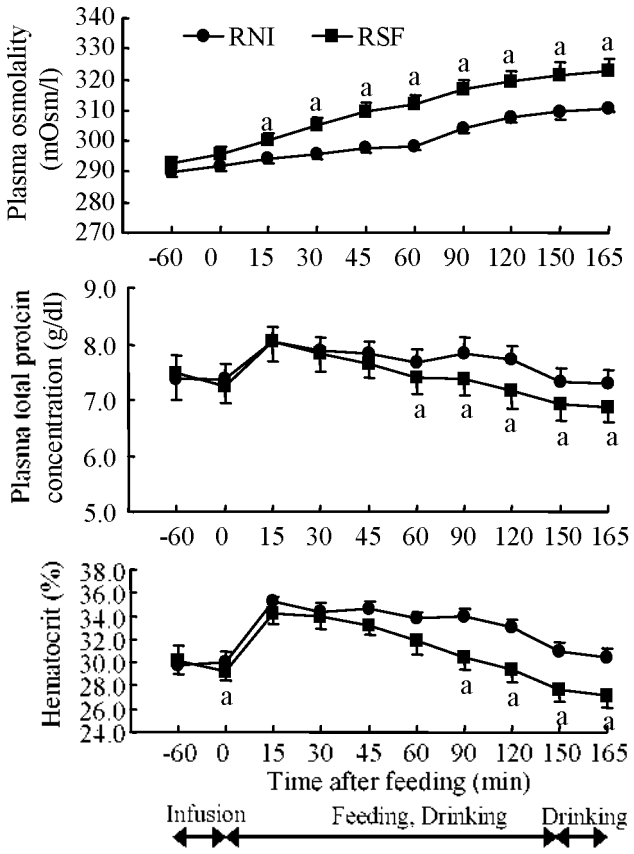

Figure 3. The effect of intraruminal infusion of parotid saliva (RSF) on plasma osmolality, plasma total protein concentration and hematocrit in goats with free access to water.Values are means±S.E. (n=5) of five goats. Significance differences between RSF and no infusion treatment (RNI) are indicated by $^{a}p<0.05$.

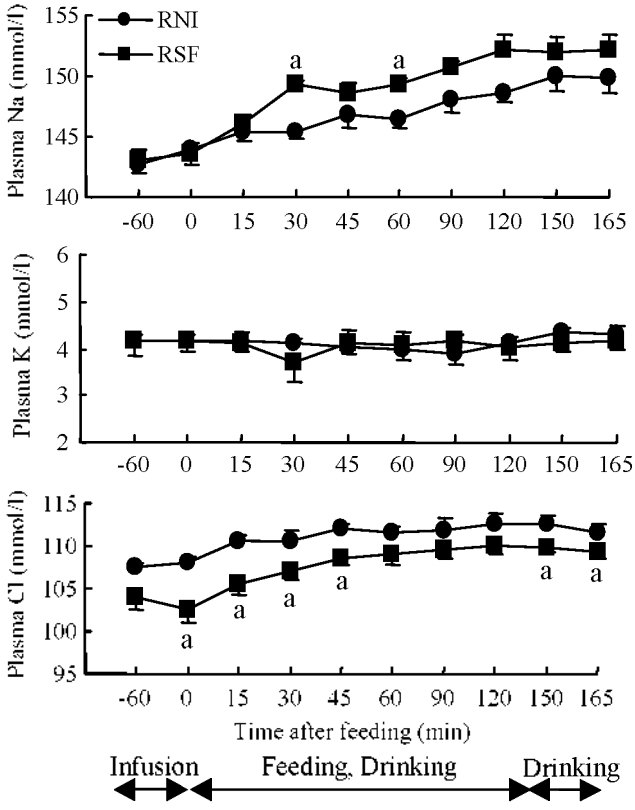

Figure 4. The effect of intraruminal infusion of parotid saliva (RSF) on plasma Na, K and Cl concentrations in goats with free access to water. Values are means±S.E. (n=5) of five goats. Significance difference between RSF and no infusion treatment (RNI) are indicated by $^{a}p<0.05$.

thirst level in the RSF treatment decreased by approximately 20.7% due to the infusion of parotid saliva. Thirst levels in the RNI and RSF treatments following the conclusion of feeding were 2,300±806 g/2h and 2,060±572 g/2h respectively. Thirst level in the RSF treatment showed only a 10% decrease and was not significantly different from the level in the RNI treatment.

Plasma concentrations of osmolality, total protein, hematocrit, Na, K and Cl

Plasma concentrations of osmolality, total protein, hematocrit, Na, K and Cl are shown in Figure 3 and 4. Plasma osmolality in the RNI treatment increased very slowly with feeding, while that in the RSF treatment increased more rapidly. In comparison with the RNI treatment, plasma osmolality in the RSF treatment was significantly ($p<0.05$) higher throughout the entire period after infusion. Plasma concentrations of Na and Cl in both treatments increased slowly with feeding, but the plasma K concentrations remained un-changed. In comparison with the RNI treatment, plasma Na concentrations in the RSF treatment were higher after 30 min of the feeding period had elapsed. On the other hand, plasma Cl concentrations in the RSF treatment during the first 60 min of feeding were significantly lower than those in the RNI treatment. Plasma K concentrations in the RSF treatment were similar to those in the RNI treatment.

In both treatments, total protein concentrations prior to feeding (RNI: 7.3±0.29, RSF: 7.2±0.28 g/dl) had increased 15 min after the commencement of feeding (RNI: 8.0±0.27, RSF: 8.0±0.34 g/dl). After 15 min of the feeding period had elapsed, plasma total protein concentrations gradually decreased in both treatments. Plasma total protein concentration in the RNI treatment prior to infusion (7.3±0.35 g/dl), and 60 min after infusion (7.3±0.29 g/dl), were similar. On the other hand, due to the intraruminal infusion of parotid saliva, plasma total protein concentration in the RSF treatment decreased approximately 4.0% from a pre-infusion level of 7.5±0.31 g/dl to a level of 7.2±0.28 g/dl 60 min after infusion. Plasma total protein concentrations in the RSF treatment showed a tendency to decrease compared to those of the RNI treatment for the first hour of the feeding period. The

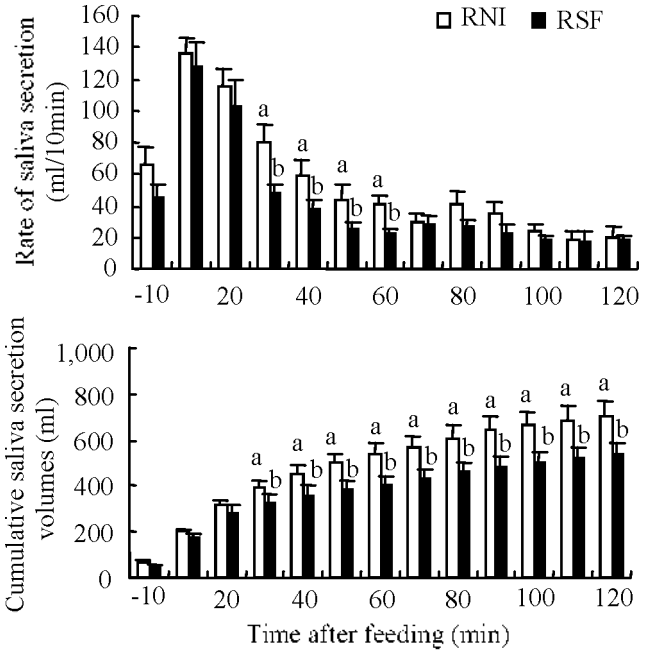

Figure 5. The effect of intraruminal infusion of parotid saliva (RSF) on saliva secration and cumulative saliva secration in goats with free access to water. Values are means±S.E. (n=5) of five goats. [a, b] Means with different superscripts are significantly different from no infusion treatment (RNI, $p<0.05$).

values in the RSF treatment decreased significantly ($p<0.05$) in the second hour.

In both treatments, hematocrit prior to feeding (RNI: 30.0±0.89, RSF: 29.2±0.73%) had markedly increased 15 min after the commencement of feeding (RNI: 35.2±0.49, RSF: 34.2±0.97%). However, hematocrit gradually decreased in both treatments for the remainder of the feeding. Hematocrit in the RNI treatment prior to infusion (29.8±0.86%), and 60 min after infusion (30.0±0.89%), were similar. On the other hand, due to the intraruminal infusion of parotid saliva, hematocrit in the RSF treatment decreased approximately 3.3 % from a pre-infusion level of 30.2±1.24% to a level of 29.2±0.73% 60 min after infusion. Hematocrit values in the RSF treatment showed a tendency to decrease compared to those of the RNI treatment for the first hour of the feeding period. The values in the RSF treatment were significantly ($p<0.05$) lower in the second hour.

Saliva secretion rates and cumulative parotid saliva secretion

Secretion rates of parotid saliva and cumulative parotid saliva secretion are shown in Figure 5. The rates of parotid saliva secretion in both treatments peaked for the first 10 min after feeding was commenced (RNI: before feeding 65±11 ml/10 min, 0 to 10 min 136±10 ml/10 min, RSF:

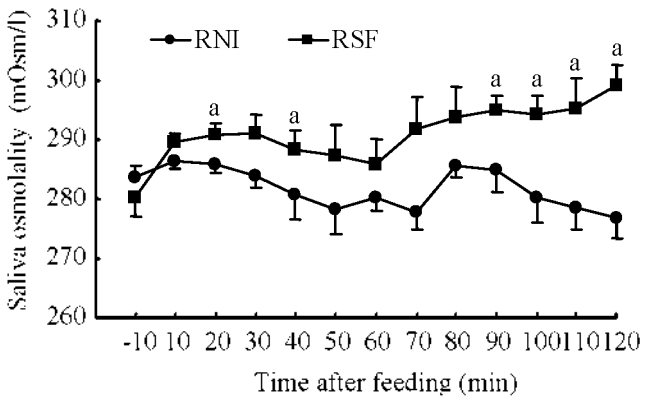

Figure 6. The effect of intraruminal infusion of parotid saliva (RSF) on saliva osmolality during feeding in goats with free access to water. Values are means±S.E. (n=5) of five goats. Significance differences between RSF and no infusion treatment (NI) are indicated by [a] $p<0.05$.

before feeding 45±7 ml/10 min, 0 to 10 min 127±16 ml/10 min). These rates then decreased as the feeding progressed. Saliva secretion rates in the RNI treatment slowly decreased until 50 min of the feeding period had elapsed, while the rates observed in the RSF treatment decreased more rapidly. The saliva secretion rates in the RSF treatment were lower than those in the RNI treatment during the time period between 30 and 60 min of the 2 h feeding period.

Cumulative saliva secretion volumes upon conclusion of the 2 h feeding period were 706±64 in RNI treatment, and 537±52 ml/2h in the RSF treatment. Cumulative saliva secretion volume in the RSF treatment showed a significant 29.3% decrease when compared to the RNI treatment.

Saliva osmolality

Saliva osmolality is shown in Figure 6. Saliva osmolality prior to feeding commencement and in the first 10 min of the feeding period was similar in both RNI and RSF treatments. However, after the first 10 min of the feeding period had elapsed, saliva osmolality in the RSF treatment was significantly ($p<0.05$) higher than that in the RNI treatment throughout the entire period of feeding. Levels in parotid saliva osmolality prior to, during and after feeding were lower than those in plasma osmolality.

DISCUSSION

Sato (1975) reported that when sheep were intraruminally loaded with water prior to feeding, increases in plasma osmolality were impeded and the marked suppression of parotid saliva secretion after the conclusion of the 2 h feeding period did not occur. Furthermore, when plasma osmolality was experimentally increased through an intravenous infusion of hyper-osmotic mannitol solution

and hyper-osmotic NaCl solution, saliva secretion was suppressed. In the present experiment, saliva secretion rates between 30 min and 60 min of the feeding period in the RSF treatment were lower than the rate observed in the RNI treatment over the same time period (Figure 5). Warner and Stacy (1977) reported that there was a negative correlation among saliva secretion rates, ruminal fluid osmolality and plasma osmolality through intraruminal or intravenous infusion of hyper-osmotic solutions. Sato (1975), Warner and Stacy (1977) indicated that when plasma osmolality increased to a pharmacological level through intraruminal or intravenous infusion of hyper-osmotic solution, parotid saliva secretion volumes were suppressed in sheep. In the present experiment, we found that when plasma osmolality increased to a physiological level through intraruminal infusion of parotid saliva, parotid saliva secretion during feeding was suppressed in goats. From these results, it is thought that the suppression of parotid saliva secretion during feeding was the result of an increase in plasma osmolality brought about by the increased intraruminal saliva flow.

It was reported that the feed intake of alfalfa pellets was regulated by changes in ruminal fluid osmolality (Baile et al. 1969; Kato et al. 1979; Grovum, 1995). The same sized dose of hyper-osmotic NaCl, polyethylene glycol-400 (PEG), sodium acetate or sodium propionate produced the same increases in rumen fluid osmolality when intraruminally infused. These increases in rumen fluid osmolality resulted in the same sized decrease in feed intake (Grovum, 1995). On the other hand, when the ruminal fluid osmolality was decreased by the intraruminal infusion of an excessive amount of warm water (39.8°C) in sheep fed on alfalfa hay cubes, feed intake increased by 30% (Sunagawa et al., 2002b). It was thought that the changes in ruminal fluid osmolality were sensed by the osmoreceptors in the rumen wall and these signals were then transported to the central nervous system (Leek and Harding, 1975). However, the effect of internal humoral factors on the intake of grass has not been investigated under these experimental conditions. Campling and Balch (1961), and Anil et al. (1993) reported that when a balloon was inserted into the rumen to restrict rumen capacity of cows fed on hay and silage, feed intake decreased. Hidari (1987) reported that when sheep free access to hay reached a certain level of rumen fill, they stopped feeding. On the other hand, Kato (1977) compared feeding times and feed intake in sheep with an esophagus fistula under normal feeding and sham feeding conditions. The animals were fed fresh grass, hay and concentrated feed. Feeding time and feed intake under sham feeding conditions tended to be slightly greater than normal feeding conditions whereby ingested matter is allowed to enter the rumen. This difference however, was not significant. This result suggests that despite the consumed feed not entering the rumen, some extraruminal mechanism exists to suppress grass intake.

In the present experiment, goats eating crushed alfalfa hay cubes secreted large volumes of parotid saliva during the first 40 min after the commencement of feeding (Figure 5). Parotid saliva has rich $NaHCO_3$ and fluid, and its secretion volumes are largest in the salivary glands. Parotid saliva secreted in large quantities has been considered to be the fluid supply for the non-secretory rumino-reticulum (Kay, 1966) and create an environment of microbial fermentation in the rumen. However, parotid saliva secreted in large volumes during the early stages of feeding must make severe demands on the sodium and water in the circulation. In the intra-ruminal iso-osmotic saline-loading experiment, Mathai et al. (2001) recorded an increased plasma and cerebrospinal fluid sodium concentration during feeding, yet water intake was reduced in comparison with untreated control group. The sensation of thirst is produced in the brain as a result of the integration of neuronal and humoral information (Fitzsimons, 1979). Neuronal information is transported via the autonomic nerves (especially the vagus) from chemoreceptors in the internal visceral organs. A broad range of internal humoral information is transported via the blood and cerebrospinal fluid. Increased extracelluer fluid osmolality, decreases in extracelluer fluid volume and arterial pressure, angiotensin II, and dryness of the mouth stimulate the secretion of thirst (Guyton and Hall, 1996). Plasma osmolality in the RSF treatment increased by approximately 3.2% with intraruminal infusion of parotid saliva prior to the commencement of feeding. The increases in plasma osmolality of the RSF treatment were brought about by increases in plasma Na concentration that was absorbed via rumen after intraruminal infusion of parotid saliva (Figure 4). However, in the RSF treatment, hematocrit and plasma total protein concentration decreased by 3.3 and 3.2%, respectively (Figure 3). Plasma total protein consists of albumin (40-50%), α-globulin (12-17%), β-globulin (8-12%), γ-globulin (25-33%) and fibrinogen (3-8%) in adult cow (Tsuda, 1994). Diurnal changes of both plasma total protein concentrations and hematocrit values reflect variations in the circulating plasma volume (Blair-West et al., 1988). These results indicate that central receptors for plasma osmolality did not completely determine thirst levels in response to feeding because animals intraruminally infused with parotid saliva did not drink more water despite having a higher plasma osmolality than that in the non-infusion treatment. Sunagawa et al. (2001, 2002a) intravenously infused in goats fed alfalfa hay cubes twice a day with an iso-osmotic mannitol solution. The infusions were conducted from 1 h prior to feeding and continued

Table 1. The relationships among feed intake, thirst levels and exogenous intraruminal fluid flow in goats

Treatments	Cumulative feed intake (g DM/2h)	Cumulative saliva secretion from unilateral parotid salivary duct (ml/2h)	Exogenous intraruminal fluid flow during feeding (ml/2h)	Thirst levels (water appetite) upon the conclusion of feeding(g/30min)
NI	1,100±243[a]	828±59[a]	0	6,400±1,170[a]
RSI	1,532±290[b]	531±32[b]	5,000	5,760±700[a]
RWI	1,605±278[b]	811±39[a]	5,000	3,210±500[b]
RNI	1,596±376[b]	705±64[a]	6,262	2,875±651[b]
RSF	1,912±352[c]	537±52[b]	9,300	2,060±572[c]

Goats with a parotid fistula were used in these experiments. Parotid saliva from the fistula was collected over 24 h. and infused into the rumen each day prior to mornig feeding. NI. RSI and RWI treatments were non-infusion. intraruminal infusion of parotid saliva or warm water (36°C). respectively (Sunagawa et al., 2002b). Goats in these treatments were deprived of water during morning feeding on the day of experimentation. RNI and RSF treatments were non-infusion and intraruminal infusion of parotid saliva in goats with free access to water throughout all day. [a,b,c] Means wih different superscripts are significantly different among each treatments ($p<0.05$).

until 1 h of a 2 h feeding period had elapsed. This infusion supplements the fluid in the blood lost through accelerated saliva secretion during the early stages of dry forage feeding. It was reported that thirst levels decreased approximately 13% while accumulated feed intake increased 43% with iso-osmotic mannitol solution. From these results. it is thought that the suppression of feed intake of dry forage in goats is not simply a result of rumen fill but also the result of thirst sensations that are produced in the brain through hypovolemia caused by the accelerated secretion of parotid saliva during the initial stages of feeding.

Sunagawa et al. (2002b) used the same animals and experimental methods to investigate the effects of intraruminal infusion of parotid saliva and warm water (36°C) on feed intake in water-deprived goats during feeding. The results of that experiment and of the present experiment have been grouped and are shown Table 1. Cumulative feed intake (Y) was linearly and positively correlated to the increase in exogenous intraruminal fluid flow (X_1), $Y=1114+0.089X_1$, $r=0.99$. However. the cumulative feed intake was also linearly and negatively correlated to the increase in thirst levels (X_2), $Y=2084-0.132X_2$, $r=0.86$. Additionally. between exogenous intraruminal fluid flow (X_1) and thirst levels (X_2). the correlation equation $X_1=6403-0.480X_2$, $r=0.82$ was obtained. From these results. it is thought that exogenous intraruminal fluid flow decreased thirst levels caused by feeding induced hypovolemia in goats fed on dry forage, and relieved a suppression of feed intake during the early stages of feeding.

The results of the present experiment suggest that a suppression of dry forage intake during the early stages of feeding in goats is partly caused by feeding induced hypovolemia. which is produced by the accelerated secretion of parotid saliva.

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