A Nutritional Study of Yeso Sika Deer (*Cervus Nippon Yesoensis*) under Farming - Review -

T. Masuko* and Y. Ishijima
Faculty of Bioindustry, Tokyo University of Agriculture, 196 Yasaka, Abashiri-shi 099-2493, Japan

ABSTRACT : Yeso sika deer (*Cervus nippon yesoensis*) grazed on various types of plants, and the fiber content in these plants was low. The tastes of yeso sika deer for existing feeds for ruminant livestock resembled those of sheep. Though the digestibility of these feeds in yeso sika deer was slightly lower than that in sheep, the nutritive values of DCP and TDN were similar between the two species, suggesting that feed for sheep can be utilized. Therefore, in small-scale farming of yeso sika deer, the feeding amount in feeding planning can be determined using the feeding standards for sheep. However, when concentrates are fed, correction of TDN is necessary. In large-scale pasturage, the nutritional intake in summer is adequate because yeso sika deer graze on various types of wild plants. In winter, they mainly graze on sasa (*Sasa senanensis*), and supplementary food may be necessary to supply TDN. Thus, since yeso sika deer graze on many types of wild plants, existing feeds for ruminant livestock can be used. In addition, plant biomasses except concentrates that do not cause competition with existing livestock may be effectively utilized in yeso sika deer, suggesting their importance as animal resources. The data on the intake and nutritive values of *Sasa senanensis* can be parameters for estimating the appropriate inhabitant number of wild yeso sika deer in wintering areas. (*Asian-Aust. J. Anim. Sci. 2001. Vol. 14, No. 5 : 701-709*)

Key Words : Yeso Sika Deer, Intake, Feeding, Digestibility, Nitrogen Balance

INTRODUCTION

Deer farming to produce velvet antlers or venison is performed using sika deer (*Cervus nippon*), red deer (*Cervus elaphus*), rusa deer (*Cervus timorensis*), sambar (*Cervus unicolor*), and fallow deer (*Dama dama*) in Oceania, Europe, and Asia (Fennessy and Taylor, 1989; Fletcher, 1989; Drew et al., 1989). At present, the number of sika deer being farmed is the highest in China, and that of red deer is the highest in New Zealand. In Japan, about 3 t velvet is annually imported from China and Taiwan and about 300 t venison from New Zealand (Yokohama et al., 1991).

In such a background, deer farming has attracted attention in Japan where 6 subspecies of wild sika deer live. In Japan, deer farming was initiated in the middle 1980s. Since capture of wild deer is legally restricted, sika deer that have been maintained in zoos and parks in Japan, those imported from China and Taiwan, and red deer are bred at present.

In recent years, yeso sika deer (*Cervus nippon yesoensis*), which is the largest in size and number among the subspecies of sika deer in Japan and distributed in Hokkaido, have attracted attention for deer farming. At our laboratory, yeso sika deer were introduced in 1990, and studies from nutritional, managerial, reproductive, and physiological aspects were initiated to establish farming techniques for yeso sika deer. Yokohama et al. reported morphological variations of antlers (1997, 1998), and examined genetic markers (1995a, 1995b). Kameyama et al. (2000) and Takeoka et al. (2000) reported changes in the plasma testosterone concentration and blood properties, respectively, during the year. Ishijima et al. (1993) and Kurosaku et al. (1996) evaluated seasonal changes in spermatogenesis while Kasai et al. (1996, 1999) analyzed the characteristics of the meat components of yeso sika deer.

The history of nutritional studies in deer in Japan is short. There have been only a few studies such as on the digestibility of Zoysia-type grass in sika deer in the Nara Park by Miyazaki et al. (1984), feed digestibility and digestive tract passage rate of sika deer by Katoh et al. (1991), digestion tests using corn silage by Ikeda et al. (1991), and the tastes for 18 types of feed such as grasses and hay cubes by Saito et al. (1990). In other countries, there have been studies on general behavior and reproductive behavior in wild red deer and *Cervus albirostris* (Lincoln, 1992; Struhsaker, 1966), digestion and seasonal changes in feed intake in red deer and fallow deer under farming (Ramanzin et al., 1997; Scott et al., 1988). In New Zealand an advanced deer farming country, Barry et al. (Barry and Wilson, 1990; Barry et al., 1991) have been leading research; they recently evaluated the association between feed intake and the endocrine system and reported results of studies on feed intake control (such as prevention of a decrease in feed intake in winter).

For farming of yeso sika deer, their ecological

* Address reprint request to T. Masuko. Fax: +81(0)-152-48-2940, E-mail: t-masuko@bioindustry.nodai.ac.jp.
Received January 4, 2001; Accepted January 4, 2001

characteristics should be clarified, and management techniques based on feeding and nutritional data should be established. The farming methods for yeso sika deer are classified into large-scale pasturage using natural geographical features and small-scale farming using new or existing farming facilities. Therefore, feed types, feed intake, and nutritive values appropriate for each method should be clarified.

To collect basic nutritional data on farming of yeso sika deer, we carried out studies on 1) types of plants grazed on by wild yeso sika deer, 2) useful feed types for their farming, and 3) utilization of plant resources not yet used for yeso sika deer. In 1), to evaluate feed intake and the composition of plants grazed on by wild yeso sika deer, the gastric contents in wild yeso sika deer were weighed, and feed intake per body weight was determined. The herbaceous plants and arboreous plants grazed on by yeso sika deer were determined, and the contents of their components were measured. In addition, the *in vitro* dry matter digestibility of arboreous plants was measured, and feed characteristics were evaluated. In 2), to evaluate the intake and digestibility of feeds that are actually used in farming of yeso sika farming, i.e., roughage and concentrates, taste tests, grazing tests, and digestion tests were performed. Hay, silage, and sasa were fed in taste tests, and hay in grazing tests. In digestion tests, hay and silage were supplied as roughage, and wheat bran and soybean meal as concentrates. In 3), noting *Sasa senanensis* that can be an important feed resource in winter in large-scale farming of yeso sika deer in areas between mountains, its intake and nutritional values were examined (Masuko and Souma, 1999; Masuko et al., 2000).

In this review, feeds and nutritional management methods in farming of yeso sika deer obtained in these studies are introduced.

COMPOSITION OF PLANTS GRAZED ON BY WILD YESO SIKA DEER

Gastric contents in wild yeso sika deer

The rumen of wild yeso sika deer showed a pH of 5.52, total VFA concentration of 20.98 mmol/dl, ammonia concentration of 48.35 mg/dl, acetic acid molar ratio of 48.4%, propionic acid molar ratio of 34.3%, and 8.9×10^5/ml protozoa. The total VFA concentration, ammonia concentration, and the propionic acid molar ratio in yeso sika deer were higher, but the pH and acetic acid molar ratio were lower than those in cattle and sheep. The number of protozoa in yeso sika deer was similar to that in sheep and goats. The rumen contents included clovers and leaves. The fermentation pattern of these contents was similar to that observed in grazing on plants with a low content of structural carbohydrates (cellulose, hemicellulose, and lignin) and a high protein content (Masuko et al., 1992).

There have been only few studies on the properties of rumen contents in deer. Barry et al. (1991) compared the rumen content fluid in summer and winter between red deer and sheep fed the same feed but observed no differences excluding the ammonia concentration in summer. Saito et al. (1990) performed tests by feeding fresh grass, silage, and hay cubes to sika deer with a rumen fistula and reported that the rumen content fluid showed a pH of 6.27～7.06, ammonia concentration of 3.00～8.01 mg/dl, and the number of protozoa of $14.2\sim17.9\times10^5$/ml. These values were similar to the above-described values in cattle and sheep but differed from those in yeso sika deer reported by Masuko et al. (1992). Fermentation in the rumen widely varies according to the characteristics of consumed feed components. Therefore, this inconsistency between the two studies may be associated with differences in the rumen contents between yeso sika deer fed existing feeds and wild yeso sika deer that selectively grazed on feeds suiting their tastes.

Seasonal differences were observed in the contents. Arboreous plants such as leaves of *Sasa senanensis*, twigs, and barks in addition to herbaceous plants were observed in spring and mainly herbaceous plants in summer. In autumn and winter, root vegetables, nuts, and leaves (including dry leaves), leaves of *Sasa senanensis* were observed. These contents were similar to those of wild yeso sika deer captured for scientific purposes at Ashoro-cho within the jurisdiction of the Tokachi Municipal Office and Onbetsu-cho within the jurisdiction of the Kushiro Municipal Office in Hokkaido (Hokkaido Environmental Science Research Center, 1995). These findings suggested that yeso sika deer graze on a wide variety of feeds and like to graze on field crops and droppings from trees. A study showed that *Sasa nipponica* accounted for about 80% of stools of honshu deer obtained in Nikko in winter, and arboreous plants accounted for 90% of the gastric contents of dead deer in Nikko in spring in 1984 when a large number of deer died (Takatsuki, 1986).

The dry matter ratio in the contents of the rumen~abomasum was much higher than that reported in sheep (Tsuda, 1990), suggesting a high concentration of gastric contents in yeso sika deer (Masuko et al., 1996). The ratio of the total content weight (fresh matter weight) in the rumen and reticulum to body weight was 6.1%. This ratio has been reported to be 4.1% in roe deer, 9.0% in red deer, and 4.3% in fallow deer (Nagy and Regelin, 1975). The ratio of the rumen content weight (dry matter weight) to body

weight was nearly 1.0% (Masuko et al., 1996). Considering that the daily feed intake per body weight was 2.3~2.8% in sika deer allowed free access to alfalfa pellets and beet pulps (Tsuda et al., 1987), this ratio (1.0%) corresponded to 50% of the daily dry matter intake, suggesting adequate feed intake in wild yeso sika deer.

Compositions and grazing of herbaceous plants and arboreous plants

Souma et al. (1996) collected 13 types of herbaceous plants and 17 types of twigs, barks, endodermis, and fallen leaves of arboreous plants that are frequently grazed on by wild yeso sika deer and analyzed their compositions and also fed yeso sika deer under feeding 67 types of herbaceous and arboreous plants to determine whether they graze on these plants. When the contents of the components of herbaceous plants are compared with those of orchardgrass and timothy in the heading stage, which are general grass types, (edited by the Secretariat of Agriculture, Forestry, and Fisheries Research Council, Ministry of Agriculture, Forestry, and Fisheries, 1995), the nitrogen-free extract content was similar, but the crude protein content in the herbaceous plants was higher, being only slightly lower than that in alfalfa hay. Comparison of component contents among the twigs, barks, and fallen leaves showed a higher crude protein content in the twigs and fallen leaves than in the barks but a higher crude fat content in the barks and fallen leaves than in the twigs. On the other hand, when the component contents in the twigs, barks, and fallen leaves were compared with those in orchardgrass and timothy, the ADF and NDF contents in the twigs and barks were higher than those in these grasses, corresponding to the values in the blooming stage of each grass. The crude protein content in the fallen leaves was lower than that in these grasses.

In grazing tests, most wild plants were grazed on. However, some types of plants were not grazed on, and the grazing degree of some types of plants differed among individual deer (Souma et al., 1996).

Among plants in which grazing marks by wild yeso sika deer had been confirmed, plants such as anemones (*Anemone flaccida*) and *Lilium Glehni* were not grazed on. The reason why anemones were not grazed on may be that young sprouts and young leaves are suited for grazing on (Takatsuki, 1992), but the other parts contain a weakly toxic alkaloid substance (Hashimoto, 1986; Nakai, 1988). Concerning *Lilium Glehni*, the reason may be that parts other than the part generally grazed on by wild yeso sika deer (floral axis) were fed. These results suggested that caution should be given to these plants containing toxic substances in pasturage using natural geographical features, but plants that grow wild in farming places can be utilized.

USEFULNESS OF ROUGHAGE AND CONCENTRATES

Tastes for hay, silage, and sasa

Souma et al. (1995) evaluated the tastes of yeso sika deer for hay and silage, which are considered to be generally fed, and *Sasa senanensis*, which is grazed on by wild yeso sika deer throughout the year and notable in terms of effective utilization of resources. Yeso sika deer favored roll baled grass hay and corn silage, and alfalfa and perennial ryegrass according to grass types. These types of roughage are fed to dairy cattle but considered to be also suited for yeso sika deer. *Sasa senanensis*, together with *Sasa kurilensis* and *Sasa nipponica*, is widely distributed in Hokkaido (Toyooka et al., 1983) and suited the taste of yeso sika deer, suggesting their usefulness as feed resources. When sasa is used as feed, autumn and winter are appropriate seasons. However, when the leaves of *Sasa nipponica* are grazed on in pasturage in summer, its subsequent reproduction is known to decrease (Okubo et al., 1990). In grazing on *Sasa senanensis*, the number of deer that does not reduce its reproduction should be also maintained. High-moisture grass silage was least favored.

Comparison of tastes between yeso sika deer and sheep in terms of feed intake showed similar tastes; feed types mainly grazed on by yeso sika deer were also frequently grazed on by sheep. Ikeda et al. (1991) fed sika deer fresh grass, hay, and corn silage and observed that they did not graze on hard stalks but liked these foods. Another study on the tastes for grasses in sheep showed a preference of perennial ryegrass to orchardgrass (Sawada, 1994).

The feed intake in sika deer shows seasonal changes, decreasing in winter (Odajima et al., 1993). However, feeding of their favorite feeds during periods of decreased amounts of grazing may inhibit the decrease in nutritional intake due to the decreased feed intake.

Seasonal changes in the amount of hay grazing

In general, feed intake differs among the seasons in deer (Aagnes et al., 1996; Barry et al., 1991; Ikeda et al., 1991; Odajima et al., 1993). In yeso sika deer, seasonal changes were also observed in hay intake (Souma et al., 1998). Changes in feed intake were not associated with age or sex. These seasonal changes in feed intake may be partly due to seasonal differences in the types of plants that can be grazed on by wild deer. Deer such as red deer are known to show seasonal differences in behavior. In autumn as their

reproduction season, male deer show active reproductive behavior such as defense of harems, and a resulting marked decrease in the grazing time reduces feed intake. In female deer, their grazing behavior is prevented by male deer that form harems and surrounding male deer, which also reduces the grazing time compared with the other seasons (Souma et al., 1994).

In ruminants, changes in feed intake is considered to be affected by thermal environments and physical environments (Mimura and Morita, 1990; Okamoto, 1970). In particular, feed intake is associated with atmospheric temperature. Since body temperature is adjusted according to environmental temperature, energy consumption increases in the cold. However, in deer such as yeso sika deer, feed intake was the lowest in winter, suggesting the importance of factors other than atmospheric temperature. Concerning such factors, Barry et al. (1991) suggested an association between feed intake and hormones. Melatonin secreted from the pineal body is known as a hormone associated with seasonality (Tomioka, 1996). The major roles of melatonin are inhibition of gonad activity, development of biological rhythms, and adjustment of the circadian rhythm. The secretion of melatonin is markedly affected by light/dark cycles, i.e., daylength (Ishida, 1995; Tomioka, 1996). In an experiment in red deer, when the light/dark cycle was changed using artificial illumination, feed intake decreased with a short light length and increased in a long light length (Francoise et al., 1992). Administration of melatonin was reported to control feed intake (Barry et al., 1991).

Thus, yeso sika deer show seasonality in feed intake even when fed adequate feed under farming (table 1), and such seasonal changes appear to be associated with the endocrine system. Since feed intake and body weight of yeso sika deer decrease in winter, the feeding method and fattening period in each season should be evaluated, and inadequate nutritional intake associated with decreased feed intake from autumn to spring should be avoided in farming of yeso sika deer to obtain products.

Digestibility and nitrogen balance of hay and silage

Masuko et al. (1997) evaluated the digestibility and nitrogen balance of hay, silage, and hay cubes for yeso sika deer. There have been few studies that compared feed digestibility between deer such as honshu deer and yakushima deer and sheep (Masuko et al., 1994; Odajima et al., 1991) and no studies using yeso sika deer. In honshu deer fed alfalfa hay cubes corresponding to 2.0% body weight, the digestion rates of organic matter, ADF, and NDF were lower than those in sheep (Odajima et al., 1991). In yakushima deer fed alfalfa hay cubes corresponding to 3.0% body weight, the digestion rates of crude fibers, ADF, and NDF were similar to those in sheep. However, in yakushima deer fed roll baled grass hay, the digestion rates of NDF and hemicellulose were lower than those in sheep (Masuko et al., 1994). In yeso sika deer fed roll baled grass hay, roll baled grass silage, and alfalfa hay cubes corresponding to 1.8～2.2% body weight, the digestion rates of crude fibers and hemicellulose were slightly lower than those in sheep, but the digestion rates of the other components were similar to those in sheep. However, since the findings on the digestion rate of ADF differ from those on NDF, further detailed studies on the digestibility of fiber components are necessary.

The contents of digestible crude protein (DCP), total digestible nutrients (TDN), and digestible energy (DE) in the 3 feed types were similar between yeso sika deer and sheep. Therefore, the nutritive values in grasses fed to sheep are available for yeso sika deer.

Yeso sika deer with a particularly high urine volume showed a high urinary nitrogen excretion and a high nitrogen accumulation amount and rate compared with sheep. However, in the other yeso sika deer, the nitrogen accumulation amount and rate were similar to those in sheep (Masuko et al., 1997).

Digestibility and nitrogen balance of a hay-concentrate mixture

In yeso sika deer fed hay or silage alone, the digestion rates of crude fibers and hemicellulose were reported to be lower than those in sheep (Masuko et al., 1997). Similar findings were also reported in honshu sika deer fed alfalfa hay cubes (Odajima et al., 1991). However, yeso sika deer fed a mixture of hay and wheat bran or soybean meal showed higher digestion rates of all components than sheep (Masuko et al., 1998) (table 2). Thus, when a single grass type is fed alone, the digestion rates of fiber components

Table 1. Seasonal changes in the intake of hay in yeso sika deer

	Spring	Summer	Autumn	Winter	SEM
Intake (g/d)	1370.4^{ab}[1)]	1705.4^{a}	1172.4^{bc}	908.0^{c}	91.0
Intake (% of BW/d)	2.35^{ab}	3.01^{a}	1.88^{bc}	1.60^{c}	0.16
Intake (g/kgW$^{0.75}$/d)	64.8^{ab}	82.2^{a}	52.7^{bc}	43.9^{c}	4.2

[1)] Means value for five deer.

[2)] Means within the same row with different superscripts differ. ^{a,b,c} $p<0.05$.

Table 2. Digestibility and nutrient content of a mixture of hay and concentrate

	Hay+wheat bran			Hay+soybean meal		
	Sheep	Deer	SEM	Sheep	Deer	SEM
Digestibility (%)						
Dry matter	56.3[1)]	63.9[1)]	4.3	56.5	68.3**[2)]	2.9
Crude protein	58.0	60.1	3.9	70.1	74.7**	1.2
NFE	61.6	66.3	3.8	54.9	67.5**	2.9
NDF	52.9	61.5	4.8	55.4	67.5**	3.1
Energy	56.5	62.1	4.2	55.3	66.4**	3.0
Nutrient content						
DCP (%DM)	7.4	7.5	0.5	14.8	15.0	0.3
TDN (%DM)	57.9	63.1	3.9	55.5	65.6**	10.4
DE (Mcal/kgDM)	2.96	3.22	0.38	2.37	3.43*[2)]	0.32

[1)] Each means value for four sheep or deer.
[2)] Significant difference between deer and sheep in each treatment (* $p<0.05$ and ** $p<0.01$).

are lower in yeso sika deer than in sheep. However, when hay mixed with wheat bran with a lower fiber content or soybean meal with a higher crude protein content is fed, the total fiber digestion rate is higher in yeso sika deer than in sheep. This suggests high digestibility of a grass- concentrate mixture in yeso sika deer. This tendency was more marked using soybean meal than using wheat bran, indicating that the combination with a feed with a high protein content markedly improves the digestibility of fiber components.

After feeding hay or silage alone, the DCP, TDN, and DE contents were similar between yeso sika deer and sheep (Masuko et al., 1997). After feeding of a mixture of each type of grass and wheat bran or soybean meal, the DCP content was similar between yeso sika deer and sheep, but the TDN and DE contents were higher in yeso sika deer. This tendency was marked using the combination with soybean meal; the TDN content differed by 10.1% and the DE content by 1.06 Mcal/kg.

The digestive tubes of ruminants can be classified according to morphological characteristics into the grass eater type showing high fiber digestibility, concentrate selector type showing low fiber digestibility, and the intermediate type. Deer are classified as the intermediate type~concentrate selector type while sheep are classified as the grass eater type (Hofmann, 1988). Deer are distributed in forests and grasslands and have feed habits between the forest type (leave eater type) and grassland type (grass eater type), which is close to the feed habits in goats among ruminants such as cattle, sheep, and goats (Takatsuki, 1992). Terada et al. (1987) observed differences in the digestibility of the fiber fraction of feed between sheep and goats, suggesting that this is due to differences in the activity of rumen microorganisms and the digestive tract feed passage rate. Odajima et al. (1991) compared the digestive tract feed passage rate between honshu sika deer and sheep and observed a significantly higher rate in deer, suggesting that this is a cause of the low digestibility. After feeding a hay-concentrate mixture, the presence of the concentrate may have affected rumen microorganisms, improving the digestibility of all fiber components. With an increase in digestibility, the TDN and DE contents also improved.

The fecal nitrogen excretion in yeso sika deer was similar to or slightly lower than that in sheep while the urinary nitrogen excretion in yeso sika deer was higher than that in sheep. Therefore, both the nitrogen accumulation amount and rate in yeso sika deer were high. The urine volume in yeso sika deer was about 1.6~2.2 times that in sheep. However, due to the low nitrogen concentration in urine, the urinary nitrogen excretion in yeso sika deer was lower than that in sheep. This may cause a high nitrogen accumulation amount in yeso sika deer. Detailed analysis of urinary nitrogen is necessary to evaluate differences between yeso sika deer and sheep.

UTILIZATION OF PLANT RESOURCES NOT YET USED

Intake, digestibility, and nitrogen balance of *Sasa senanensis*

In yeso sika deer, the intake of *Sasa senanensis* differed among autumn, winter, and spring (Masuko et al., 1999) (table 3). The dry matter intake of *Sasa senanensis* per day was the highest in winter, followed in order by autumn and spring. The dry matter intake per body weight was the highest in autumn, followed in order by winter and spring. This change in the order of autumn and spring is because dry matter intake was most markedly decreased in winter, but body weight was decreased in winter compared with

Table 3. Seasonal changes in the intake of sasa (*Sasa senanensis*) in yeso sika deer

	Autumn		Spring		Difference
	Mean[1)]	SEM	Mean	SEM	
Intake (DMg/d)	956.8	146.5	1008.5	109.5	NS[2)]
Intake (% of BW/d)	1.66	0.16	1.95	0.18	$p<0.01$
Intake (DMg/kg$W^{0.75}$/d)	45.7	5.0	52.3	4.8	$p<0.01$

[1)] Means value for four deer.
[2)] Not significant.

autumn.

Souma et al. (1998) evaluated seasonal changes in dry matter intake and observed that both the hay intake per day and that per body weight increased from spring, reaching the maximum in summer, but decreased in autumn, reaching the minimum in winter. The dry matter intakes of hay per body weight were 1.99%, 2.44%, 1.58%, and 1.35% in spring, summer, autumn, and winter, respectively (table 1). The dry matter intake of *Sasa senanensis* per body weight in spring was lower, but that in autumn and winter was slightly higher than the dry matter intake of hay per body weight in each season. These results suggest that the dry matter intake of *Sasa senanensis* in yeso sika deer is similar to or higher than that of hay, and *Sasa senanensis* is an important feed resource for nutrient intake in winter.

The digestion rates of the dry matter, organic matter, and energy of *Sasa senanensis* were low (44.5~48.6%). These values were similar to those of roll baled grass silage mainly consisting of second cut orchardgrass (36.6~43.7%) (Masuko et al., 1997) among feed types used in previous digestion tests. The digestion rates of crude fibers, ADF, NDF, and hemicellulose after feeding roll baled grass silage were 37.1~51.6%, which were similar to those of *Sasa senanensis* (43.7~47.5%). However, the digestion rate of crude protein in *Sasa senanensis* (74.5%) was much higher than that in roll baled grass silage (53.5~55.2%) (Masuko et al., 1999). Masuko et al. (1998) reported a high digestion rate of crude protein (74.7%) after feeding of a hay-soybean meal mixture. The digestion rate of crude protein in *Sasa senanensis* was similar to this value. Similar findings were also reported in experiments in which sika deer were fed *Sasa palmata* (Matoba et al., 1987).

The DCP content in dry matter was markedly high (12.7%). This value was only slightly lower than that after feeding of a hay-soybean meal mixture, suggesting a high nutritive value of *Sasa senanensis* in terms of protein. However, the TDN content in dry matter was low (44.7%) since the digestion rate of each component other than protein was low, and was only slightly higher than the TDN content in roll baled grass silage.

Concerning nitrogen balance, the fecal nitrogen excretion was low, but the nitrogen accumulation amount and rate were high because of a high urinary nitrogen excretion (Masuko et al., 1999).

Changes in the composition and dry matter digestibility of *Sasa senanensis* with the growth stage

Concerning the composition of *Sasa senanensis*, the contents of dry matter, crude fat, and crude ash increased while the contents of fiber components such as crude fibers, ADF, NDF, and hemicellulose decreased from leaf-bud formation to withering, but changes from October to June next year were slight (Souma et al., 1999). In general, the composition of grass fed to ruminant livestock markedly varies according to the growth stage (Morimoto, 1989). In orchardgrass and timothy in grass, the contents of dry matter, crude fat, crude fibers, ADF, and NDF increase with the growth period, but the content of the crude ash is nearly constant (Secretariat of the Agriculture, Forestry, and Fisheries Research Council, Ministry of Agriculture, Forestry, and Fisheries, 1995). When composition changes with growth are compared between *Sasa senanensis* and grass, the patterns of changes in the contents of crude fibers, ADF, and NDF differed, showing reverse changes (Souma et al., 1999). The slight composition changes from October to June next year may be due to inhibition of growth metabolism caused by the low temperature on the ground that is sometimes buried in snow during this period.

In vitro dry matter digestibility decreased with the growth stage and changed only slightly from October to June next year, showing a pattern similar to that of composition changes (Souma et al., 1999). In general, digestibility also decreases with growth in grass, but this is mainly due to an increase in the lignin content, resulting in lignification (Nakamura, 1977; Morimoto, 1989). Lignin is slightly digestible, and an increase in lignin reduces degradation by enzymes, resulting in a decrease in digestibility. However, in *Sasa senanensis*, the contents of fiber components decreased with the growth stage, and it is unlikely that an increased lignin content reduced *in vitro* dry matter digestibility.

Concerning the components of *Sasa senanensis* other than fibers, the crude ash content markedly increased while the organic matter content decreased with the growth stage. This may have reduced *in vitro* dry matter digestibility.

From autumn to spring, the composition and dry matter digestibility of *Sasa senanensis* are relatively stable. The dry matter intake during this period is also high (Masuko et al., 1999). This suggests that a certain nutrient intake from *Sasa senanensis* is possible in yeso sika deer.

CONCLUSIONS

Yeso sika deer showed tastes for roughage similar to those in sheep but slightly lower feed digestibility than sheep. However, since the nutritive values of DCP and TDN in yeso sika deer were simlar to those in sheep, feed menus for sheep can be utilized. Therefore, in feeding planning in small-scale deer farming, the feeding amount can be determined using the feeding standards for sheep. In large-scale farming, wild plants can be used in summer. Yeso sika deer grazed on various types of plants, and the fiber component content in these plants was low. Thus, from summer to autumn when wild plants can be used, adequate nutritional intake may be achieved. However, in winter, use of mainly *Sasa senanensis* is considered. When only *Sasa senanensis* is fed, TDN intake may be inadequate, and supplementary feed is necessary.

To reduce damage on agriculture and forestry by yeso sika deer, the number of yeso sika deer should be maintained to be appropriate. For this purpose, plants grazed on by these deer should be evaluated, and their nutritive values and reproduction amounts should be studied. However, there have been no such studies, and this study may provide data to calculate the appropriate number of wild yeso sika deer.

Yeso sika deer graze on various types of plants. Therefore, yeso sika deer may be a precious animal recourse in which plant biomasses (edited by the Secretariat of the Agriculture, Forestry, and Fisheries Research Council, Ministry of Agriculture, Forestry, and Fisheries, 1991) can be effectively used in addition to existing feeds for ruminant livestock. The data on the intake and nutritive values of *Sasa senanensis* can be parameters used for estimating the appropriate inhabitant number of wild yeso sika deer in wintering areas.

REFERENCES

Aagnes, T. H., A. S. Blix and S. D. Mathiesen. 1996. Food intake, digestibility and rumen fermentation in reindeer fed baled timothy silage in summer and winter. J. Agric. Sci. 127:517-523.

Barry, T. N., J. M. Suttie, J. A. Milne and R. N. B. Kay. 1991. Control of food intake in domesticated deer. In: Physiological aspects of digestion and metabolism in ruminants (Ed. Tsuda, T., Y. Sasaki and R. Kawashima). 385-401. Academic Press Inc. San Diego.

Barry, T. N. and P. R. Wilson. 1990. Development and present status of deer farming industry in New Zealand. -International Deer Symposium Report (II)-. Animal Husbandry. 44:1015-1021. (in Japanese)

Drew, K. R., Q. Bai and E. V. Fadeev. 1989. Deer farming in Asia. In: Wildlife production systems. Economic utilization of wild ungulates (Ed. Hudson, R. J., Drew, K. R. and L. M. Baskin). 309-345. Cambridge University Press. Cambridge.

Edited by Secretariat of Agriculture, Forestry, and Fisheries Research Council, Ministry of Agriculture, Forestry, and Fisheries. 1991. Biomass change plan-Utilization of rich biological resources-. 167-184, 651-684. Korin. Tokyo (in Japanese).

Edited by Secretariat of Agriculture, Forstry, and Fisheries Research Council, Ministry of Agriculture, Forestry, and Fisheries. 1995. Japan standard feed components table (1995). 12-183. Central Association of Livestock Industry. Tokyo (in Japanese).

Fennessy, P. F. and P. G. Taylor. 1989. Deer farming in Oceania. In: Wildlife production systems. Economic utilization of wild ungulates (Ed. Hudson, R. J., Drew, K. R. and L. M. Baskin). 309-345. Cambridge University Press. Cambridge.

Fletcher, T. J. 1989. Deer farming in Europe. In: Wildlife production systems. Economic utilization of wild ungulates (Ed. R. J. Hudson, K. R. Drew and L. M. Baskin). 309-345. Cambridge University Press. Cambridge.

Francoise, B. M. Domingue, P. R. Wilson, D. W. Dellow and T. N. Barry. 1992. Effect of subcutaneous meratonin implants during long daylength on voluntary feed intake, rumen capacity and heat rate of red deer (*Cervus elaphus*) fed on a forage diet. Br. J. Nutr. 68:77-88.

Hashimoto, I. 1986. Illustrated book of delicious wild plants 2. 97-99. Seibundo Shinkosha. Tokyo (in Japanese).

Hofmann, R. R. 1988. Aspects of digestive physiology in ruminants. 1-20. Comstock Publishing Associates, Itheca.

Hokkaido Institute of Environmental Sciences. 1995. Report of survey of inhabitant status of brown bears and yeso sika deer (I). 135-146 (in Japanese).

Ikeda, S., T. Takeda, M. Ishida and T. Saito. 1991. Feeding and digestion tendencies of sika deer (*Cervus nippon*). Rep. Miyagi Agri. Col. 38:27-36 (in Japanese).

Ishida, N. 1995. What is the biological clock?. Kogyo Gijutsu. 36:52-57 (in Japanese).

Ishijima, Y., Y. Kato, Y. Kameyama, M. Yokohama, Y. Monji and Y. Tsutsumi. 1993. Seasonal changes of spermatogenesis of yeso sika deer (*Cervus nippon yesoensis*). J. Agric. Sci., Tokyo Nogyo Daigaku. 38:208-211 (in Japanese).

Kameyama, Y., R. Takahashi, M. Ito, R. Maru and Y. Ishijima. 2000. Seasonal changes of testis volume, sctotal circumference and serum testosterone concentrations in male sika deer (*Cervus nippon*). Anim. Sci. J. 71:137-142.

Kasai, T., M. Yokohama, K. Inoue and Y. Ishijima. 1996.

Fatty acids composition in yeso sika deer (*Cervus nippon yesoensis*) living around Abashiri city. Anim. Sci. Technol. (Jpn.) 67:1086-1089.

Kasai, T., H. Sakai, Y. Ishijima and T. Hasegawa. 1999. Proximate composition, properties of lipid and mineral contents in yeso sika deer (*Cervus nippon yesoensis*) Meat. Nippon Shokuhin Kagaku Kogaku Kaishi. 46:710-718 (in Japanese).

Katoh, K., Y. Kajita, M. Odashima, M. Ohta and Y. Sasaki. 1991. Passage and digestibility of lucern (*Medicago sativa*) hay in Japanese sika deer (*Cervus nippon*) and sheep under restricts feeding. Br. J. Nutr. 66:399-405.

Kurosaki, T., Y. Kameyama and Y. Ishijima. 1996. Seasonal changes of testis volume and spermatogenesis in yeso sika deer (*Cervus nippon yesoensis*) and yakushika deer (*C. n. Yakushimae*) under housing. Anim. Sci. and Agric. Hokkaido. 38:28-31 (in Japanese).

Lincoln, Gerald A. 1992. Biology of seasonal breeding in deer. In: The biology of deer (Ed. R. D. Brown). Springer-Verlag. New York. pp. 565-574.

Masuko, T., Y. Kameyama, M. Yokohama and Y. Ishijima. 1992. Characteristics of rumen contnets in yeso sika deer (*Cervus nippon yesoensis*). Jour. Agri. Sci., Tokyo Nogyo Daigaku. 37:162-165 (in Japanese).

Masuko, T., N. Turuta and Y. Ishijima. 1994. Digestion and nitrogen utilizaton of roll baled grass hay or alfalfa hay cube in yakushima deer (*Cervus nippon yakushimae*) and sheep. Anim. Sci. and Agric. Hokkaido. 36:67-70 (in Japanese).

Masuko, T., K. Souma and Y. Ishijima. 1996. The amoumt of rumen contents in wild yeso sika deer (*Cervus nippon yesoensis*). Grassland Science. 42:176-177 (in Japanese).

Masuko, T., K. Souma, H. Kumagai, K. Takasaki, Y. Kameyama and Y. Ishijima. 1997. Digestibility and nitrogen balance in yeso sika deer (*Cervus nippon yesoensis*) fed round baled hay, alfalfa hay cube and round baled silage. Grassland Science. 43:32-36 (in Japanese).

Masuko, T., K. Souma, M. Fujii, K. Takasaki and Y. Ishijima. 1998. Digestibility and nitrogen balance in yeso sika deer (*Cervus nippon yesoensis*) fed mixtured of hay and wheat bran or soybean meal. Anim. Sci. and Agric. Hokkaido. 40:22-26 (in Japanese).

Masuko, T., K. Souma, K. Miyairi, T. Komatsu and Y. Ishijima. 1999. Intake, digestibility and nitrogen balance of sasa (*Sasa senanensis*) in yeso sika deer (*Cervus nippon yesoensis*). Anim. Sci. and Agric. Hokkaido. 41:72-75 (in Japanese).

Masuko, T. and K. Souma. 1999. Studies of nutrition in yeso deer feeding. Anim. Sci. and Agric. Hokkaido. 41:1-9 (in Japanese).

Masuko, T., T. Taji, K. Nakamura, M. Sekikawa and S. Masaoka. 2000. Deer products utilization handbook. 1-19. Zennipon Youroku Kyoukai. Tokyo (in Japanese).

Matoba, K., T. Nakamura, S. Sato, T. Watanabe, M. Odajima, K. Usa and H. Tamate. 1987. Feed utilization in sika deer. Kawatabi Farm Report. 3:158-159 (in Japanese).

Mimura, K. and T. Morita. 1990. Kachiku Kanrigaku 6 th edition. 64-87, 169-171. Yokendo LTD. Tokyo (in Japanese).

Miyazaki, A., S. Kasagi and T. Mizuno. 1984. Digestibility of Zoysia-type grass by Japanese deer. Jpn. J. Zootech. Sci. 55:661-669.

Morimoto, H. 1989. Revised Nutrition 17 th edition. 173-176, 199-296, 333-344. Yokendo LTD. Tokyo (in Japanese).

Nagy, J. G. and W. L. Regelin. 1975. Comparison of digestive organ size of three deer species. J. Wildl. Manage. 39:621-624.

Nakamura, S. 1988. Methods of identifying 100 familiar poisonous herbs. 37-38, 47-50. Kinensha. Tokyo (in Japanese).

Nakamura, R. 1977. New feed study Volume 1. General remarks. 27-28. Chikusan Shuppansha. Tokyo (in Japanese).

Odajima, M., Y. Kajita, K. T. Nam, S. R. Lee, H. Senge, K. Katoh, Y. Shoji, M. Ohta and Y. Sasaki. 1991. Seasonal changes in food passage and digestibility in Japanese sika deer (*Cervus nippon*) and sheep under restricted feeding condition. Anim. Sci. Technol. (Jpn.) 62:308-313 (in Japanese).

Odajima, M., K. Nakajima, Y. Ohtomo, S. Oda, Y. Shoji, K. Katoh, M. Ohta and Y. Sasaki. 1993. Year-long changes in food intake and body weight in group-fed Japanese sika deer (*Cervus nippon*). Anim. Sci. Technol. (Jpn.) 64:421-423 (in Japanese).

Okubo, T., H. Hirota, Y. Takasaki, A. Ueno, S. Saiga, K. Ataku, H. Kobayashi, T. Shimada, M. Kikuchi and I. Nakanishi. 1990. Grassland Study. 28-32. Buneido. Tokyo (in Japanese).

Okamoto, S. 1970. Environment and physiology of live-stock · poultry. Yokendo LTD. Tokyo (in Japanese). pp. 89-116.

Ramanzin, M., L. Bailoni and S. Schiavon. 1997. Effect of forage to concentrate ratio on comparative digestion in sheep, goats and fallow deer. Anim. Sci. 64:163-170.

Saito, T. (Representative of researchers). 1990. Intensive breeding management techniques for sika deer as new meat resources and development of utilization of venison. Report of study supported by grant-in-aid for scientific research (fiscal 1988). Department of Animal Husbandry, Miyagi Agricultural Junior College. Miyagi (in Japanese). pp. 1-128.

Sawada, Y. 1994. Study on improvement and utilization of pasture, and on evaluation of grazing characteristics of temperate grasses. J. Hokkaido Grassl. Sci. 28:1-5 (in Japanese).

Scott, E. Henke, S. Demarais and A. James, Pfister. 1988. Digestive capacity and diet of white-tailed deer and exotic ruminants. J. Wildl. Manage. 52:595-598.

Souma, K., T. Masuko and Y. Ishijima. 1994. General behavior of the sika deer (*Cervus nippon*) under housing. Anim. Sci. and Agric. Hokkaido. 36:57-62 (in Japanese).

Souma, K., Y. Honda, T. Masuko and Y. Ishijima. 1995. The palatability of hay, silage and sasa (*Sasa senanensis*) on the yeso sika deer (*Cervus nippon yesoensis*). Anim. Sci. and Agric. Hokkaido. 37:28-34 (in Japanese).

Souma, K., T. Masuko, R. Kitahara and Y. Ishijima. 1996. Intake of wild herbaceous and arboreous plant in the yeso sika deer (*Cervus nippon yesoensis*) and its chemical composition. Anim. Sci. and Agric. Hokkaido. 38:98-104 (in Japanese).

Souma, K., T. Masuko, Y. Kobayashi and Y. Ishijima.

1998. Seasonal alteration of hay intake in the yeso sika deer (*Cervus nippon yesoensis*). Anim. Sci. and Agric. Hokkaido. 40:27-30 (in Japanese).

Souma, K., T. Masuko, K. Miyairi, R. Kitahara, T. Komatsu and Y. Ishijima. 1999. Changes in chemical composition and *in vitro* dry matter digestibility of sasa (*Sasa senanensis*) on different growth stages. Anim. Sci. and Agric. Hokkaido. 41:76-79 (in Japanese).

Struhsaker Thomas, T. 1966. Behaviour of Elk (*Cervus canadensis*) during the rut. Z. Tierpsychol. 24:80-114.

Takatsuki, S. 1986. Analysis of gastric contents of dead deer in mass deaths in Nikko in 1984. Hakukenpo, Tochigi Prefecture. 4:15-22 (in Japanese).

Takatsuki, S. 1992. Deer in the north-Ecology of deer, sasa, and snow-. 115-132. Dobutsusha. Tokyo (in Japanese).

Takeoka, R., Y. Kameyama and Y. Ishijima. 2000. Blood properties in farmed male yeso sika deer. Anim. Sci. and Agric. Hokkaido. 42:25-28 (in Japanese).

Terada, F., R. Tano, K. Iwasaki and T. Haryu. 1987. Comparison of nutritive values among cattle, sheep and goats fed the same diets. Jpn. Zootech. Sci. 58:131-137 (in Japanese).

Tomioka, K. 1996. Creatures that know time. Shokabo. Tokyo (in Japanese). pp. 127-135.

Toyooka, K., A. Sato and M. Ishizuka. 1983. Distribution map of the sasa group in Hokkaido explanatory note. 1-36. Hokkaido Branch For. Prod. Res. Inst. Hokkaido (in Japanese).

Tsuda, T., I. Ito, T. Hoshino, S. Nishiguchi, Y. Sasaki and M. Ohta. 1987. Physiological · ecological study of productivity of sika deer. Report of a grant-supported study of meat. Itoh Science Foundation. Tokyo (in Japanese). 5:147-153.

Tsuda, T. 1990. Livestock Physiology 9 th edition. 61-62, 177-180, 206-207. Yokendo LTD. Tokyo (in Japanese).

Yokohama, M., Y. Kameyama, T. Masuko, T. Komatsu, R. Hashizume and Y. Ishijima. 1991. An investigation on the merits of the animal resouces of the yeso sika deer (*Cervus nippon yesoensis*). Jour. Agri. Sci., Tokyo Nogyo Daigaku. 35:185-191 (in Japanese).

Yokohama, M., T. Yamazaki and Y. Ishijima. 1995a. Red cell protein types and restriction endonuclease cleavage patterns of mtDNA in the yeso sika (*Cervus nippon yesoensis*). Jour. Agri. Sci. Tokyo Nogyo Daigaku. 39:303-307 (in Japanese).

Yokohama, M. and Y. Ishijima. 1995b. Albumin and transferin types of yeso sika deer (*Cervus nippon yesoensis*) and raindeer (*Rangifer tarandus tarandus*). J. Anim. Genet. 23:49-50 (in Japanese).

Yokohama, M., H. Hoshi, Y. Masuda, T. Yamamoto and Y. Ishijima. 1997. Morphological variations of antler in yeso sika deer (*Cervus nippon yesoensis*). Jour. Agri. Sci., Tokyo Nogyo Daigaku. 42:113-121 (in Japanese).

Yokohama, M., H. Hoshi, T. Yamamoto and Y. Ishijima. 1998. Symmetric antler conformation in yeso sika deer (*Cervus nippon yesoensis*). J. Agri. Sci., Tokyo Nogyo Daigaku. 42:247-251 (in Japanese).