no sign of hepatitis. Treatment with D-mannitol (an · OH scavenger) to LEC rats suppressed the increases in serum aspartate aminotransferase activity and total bilirubin concentration. D-mannitol also significantly reduced hepatic mitochondrial LPO, a process which is important in the pathogenesis of Cu-induced hepatotoxicity. The author showed the first in vivo evidence of accelerated · OH generation in the livers of hepatitic LEC rats, and this increase in · OH generation may play important roles in the development of acute hepatitis.

3) α-Lipoic acid has ROS quenching and metal chelating activities. DL-α-lipoic acid (LA) was administered to LEC rats by gavage at doses of 10, 30 and 100mg/kg five times per week, for 4 weeks. LA prevented severe jaundice in a dose-dependent manner. Antioxidant system analyses in liver showed that LA treatment significantly suppressed the inactivations of CAT and glutathione peroxidase, as well as the induction of heme oxygenase-1. LA at the highest dose slightly suppressed the accumulation of Cu in crude mitochondrial fraction, but it had no effect on the accumulation of Cu in cytosolic fraction. While the increase in LPO in the microsomal fraction was completely suppressed by LA at the highest dose, the suppressive effect against LPO in crude mitochondrial fractions was slight. On the basis of these results, the author concluded that LA has antioxidant effects at the molecular level against the development of Cu-induced hepatitis in LEC rats. Moreover, mitochondrial oxidative damage might be important for the development of acute hepatitis in LEC rats.

Nutritional status of sika deer (*Cervus nippon yesoensis* Heude) in eastern Hokkaido, Japan

Mayumi Yokoyama

Laboratory of Wildlife Biology,
Graduate School of Veterinary Medicine,
Hokkaido University, Sapporo 060-0818

Nutritional status of wild ungulate provides important information on population status, because it affects winter survival, reproductive rate, fetal growth, and body size. Sika deer (*Cervus nippon* Temminck) in Japan were shown to have a wide range of adaptability to their habitat. Few studies of nutritional strategy, however, have investigated sika deer. Hokkaido sika deer (*C. n. yesoensis* Heude) are widely distributed in eastern Hokkaido, which has the most severe winter condition in Japan. The basic information on nutritional ecology will help us to understand the key factor of their life history, adaptation to the dynamism of their environment, and their management.

This study was designed to understand the characteristics of nutritional ecology of Hokkaido sika deer seasonally, and to set up the standard for nutritional assessment of the population. For the fundamental study, qualitative and quantitative analyses of food habits and nutritional value of sika deer diets were conducted. Second, to evaluate the nutritional status of the population, seasonal changes of fat indices were investigated and their thresholds for winter survival were estimated. The last morphological characteristics and growth pattern based on mandible measurements were analyzed. I collected controlled-killed, research-purpose-killed, and winter-killed deer in eastern Hokkaido.

Rumen content analysis and field observations were used to investigate food habits and diet quality of sika deer from 1991-1993. 140 rumen samples were collected in the Ashoro and Onbetsu district. Bite marks observations were surveyed and main species of sika deer diets were collected for chemical analysis in four areas in the Ashoro district. The following results were obtained :

1. Diets varied seasonally, with deer using graminoids and browse in winter, forbs and agricultural crops in spring and summer, and all of these plant foods in fall in rumen.
1. Eighty-four plant species with sika deer bite marks were identified, and their use also varied seasonally.
2. The diversity of food resources available provided both critical protein and digestible energy, allowing for physiological maintenance and seasonal growth. With these high quality diets, deer maintained good body conditions in eastern Hokkaido, where the population density was relatively low.

I analyzed seasonal and sexual changes in kidney mass (KM) and kidney fat mass (KFM) as indices of condition in Hokkaido sika deer. For 76 male and 132 female sika deer, seasonal fluctuations in KM and KFM fitted with sine wave growth curves as follows, $Y = A\{1 - \frac{1}{3} e^{-K(t-I)}\}^3 \ (C \sin[2\pi t/12 - \phi])$. The following results were obtained :

1. Growth parameters for KM and KFM were fitted to the von Bertalanffy confined sine wave significantly ($P < 0.001$ for all cases). Both males and females demonstrated a winter KM loss of 54% and 52%, respectively. The maximum KM occurred in early August, and the minimum in early February in both sexes (not sinificatly different between sexes. $P > 0.1$).
2. KFM increased rapidly until the 3 rd month and attained an asymptotic level at 15 months after birth in both sexes. The asymptotic mass (A) of KFM in males was significantly less than that in females ($P <$ 001). In the KFM model, males and females represents winter fat mobilization of 97% and 76%, respectively. The timing of seasonal fluctuations in KFM was not statistically significant between the sexes ($P > 0.1$). Maximum KFM occurred in mid October, and the minimum in mid April.
3. Although the kidney fat index (KFI) is based on the assumption that kidney mass is proportional to body mass in all seasons, our data did not support this assumption. Kidney fat mass was a better index of Hokkaido sika deer condition than KFI.
4. Although sex-based differences in Cervids KFM are said to reflect differences in reproductive cycles, the seasonal similarities in sika deer KFM levels might represent adaptations to the long, severe Hokkaido winter. Because deer populations in our study were at low densities and had high pregnancy rates, our sine wave growth models are presented as bases of fat level fluctuations in Hokkaido sika deer.

I derived fat indices for sika deer in eastern Hokkaido, and estimated the probability of over-winter survival with a logistic regression model using fat indices. Variations in survival in relation to fat indices were analyzed using a linear logistic model. If p is the probability of survival, model was indicated as follows, $p = [\exp\ (\alpha + (\Sigma_i\ \beta_i\ X_i)]/\ \{1 + [\exp\ (\alpha + (\Sigma_i\ \beta_i\ X_i)]\}$. We assumed the probability of survival of controlled-killed and road-killed deer was 1 (living) and that of winter-killed deer was 0 (dying). The following results were obtained :

1. Kidney fat mass(KFM)appears to be an adequate index of a wide range of physical conditions before the onset of severe nutritional stress. When KFM values fell below 20 g, femur(FMF)and mandible cavity fat (MCF)indices declined sharply. FMF and MCF were useful indices for detecting malnourished deer.
2. A logistic regression model was used to describe survival thresholds in two bone fat indices for calves(45%)and three fat indices for adult females(FMF=25%,MCF=30%, KFM=20 g). These models were useful for estimating the probability of winter survival in Hokkaido sika deer.

Growth pattern and morphological variation of mandible

To evaluate temporal variation in mandible size that was related to nutritional condition in the habitat within eastern Hokkaido, 224 mandibles were collected from controlled-killed, research-purpose-killed and winter-killed females and calves sika deer in the Akan and Onbetsu districts. Nine measurements were selected. These measurements indicated that :

1. Growth curve of von Bertalanffy equation $Y(t) = A\{1-\frac{1}{3}\exp[-K(t-I)]\}$ was fitted to each measurement. The growth curve equation provided a good description of pattern of growth for each measurement ($P<0.001$), and indicated mandible 'length' and 'height' continue growing untill winter of 2 years old and winter of 1 year old, respectively.
2. For the evaluation of total size and shape of mandibles, I conducted a principal component analysis. Both mandibles of winter-killed and controlled-killed adult female deer in 1996-1998 were significantly smaller than mandibles of controlled-killed in 1992. There was no significant difference between each group of deer in 1996-1998.
3. In calves, winter-killed deer in 1996-1997 were the smallest, controlled-killed deer in 1997-1998 were the middle, and controlled-killed deer in 1992 were the largest.
4. Differences in mandible size that reflect differing nutritional regimes were indicated in eastern Hokkaido.
5. Body length was estimated by multiple regression analysis using nine measurements of mandible and was significant ($P<0.001$). Skeletal downsizing could be estimated using mandible measurements. The regression equation was as follow.

$$Y = -55.65 - 0.486(CL) + 1.405(DL) + 0.13(LCL) + 0.682(ML) + 1.297(DH) + 0.685(PH) + 0.123(MH) + 0.062(LH) - 0.225(CH)$$