Wildlife Nutrition

A Publication of the Canadian Association of Zoos and Aquariums
Nutrition Advisory and Research Group (CAZA-NARG)

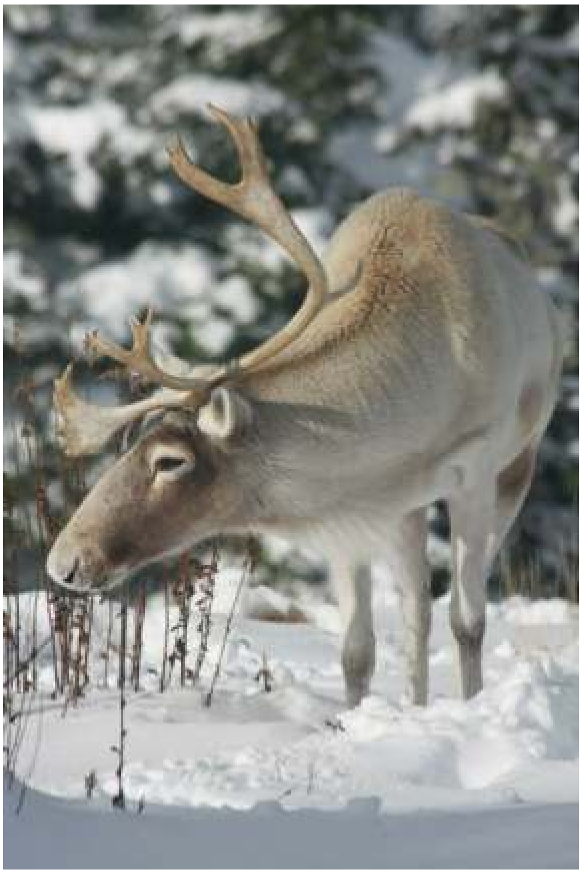
September, 2012

Our second issue provides more articles that I think you will find interesting and useful. Some of the material should be especially relevant as as we enter into the fall season.

The mandates of CAZA-NARG include education on the nutrient needs of captive wildlife and this issue continues that tradition. As always, if you have questions about the material, please contact me at any time.

The photograph at right is a teaser for some wonderful photos we are publishing with permission from the Newfoundland Wildlife Division, Salmonier Nature Park.. These photos can be found on pages 11-12.

Deb McWilliams



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"Wildlife Nutrition" is published three times yearly (January, May and September)

Do Carnivorous Species Need to Chew?

Another question I have frequently been asked over the years is about commercial diets versus prey diets for carnivore species. The article on carnivore nutrition in the last issue revived this debate. Therefore, in this issue, we will discuss commercial diets versus prey diets for carnivore species and concentrate on some of the relevant nutritional factors.

Before we begin our discussion, we must define what "chew" means when applied to carnivorous species. Carnivore species do not chew their food. They rip and tear chunks of food from prey or slabs of meat. Those chunks of food are swallowed. Therefore, as we continue through our discussion, visualize "ripping and tearing" when terms such as chew or chewing appears.

The provision of zoo animal nutrition has progressed in the past several decades. There are numerous commercial diet products designed for many species and these commercial products are convenient to use and to feed out; they generally have optimum shelf lives; and, they provide what is termed a "complete diet". "Complete diet" means that the product supplies the known nutrient requirements for that species and – usually – does not need supplementation. In many zoological institutions, these products may be the only food an animal receives and this may have the potential for disservice to captive animals. For example, commercial zoo animal diets are energy dense, palatable and usually do not require extensive chewing or digestion. While these factors can be beneficial, they can also create some problems. The problem we will discuss is in this article is the implications – ***for carnivorous species*** - of a diet that does not require chewing.

Development. Let's begin with the effect of a diet that does not require chewing on jaw structural development. Carnivores raised in captivity on soft diets often have smaller skulls and jaws than wild conspecifics. Duckler (1998) reports on captive tigers with a reduction in size of jaw muscles that also affected the formation of the external occipital protuberance and resulted in deformity. This research cited a lack of jaw activity due to processed, ground meat captive diets as a causal factor. Captive African lions, according to Zuccarelli (2004), develop smaller skulls, jaws and masticatory muscles as compared to wild lions. The smaller skulls, jaws and masticatory muscles can be linked to a reduction in jaw movement and bite force related to captive diets that do not require chewing. This research is supported by the findings of O'Regan and Kitchener (2005) who found skull sizes were smaller in captive animals as compared to wild conspecifics and diet in captivity is a factor. Their research also found that smaller skull sizes also meant smaller brain sizes.

Pathology. We continue in our discussion with some pathology that can result from feeding carnivores diets that do not provide opportunity to chew. Disease processes that can result from processed diets that do not require chewing include periodontal disease (pathology resulting from dental plaque) and trauma to bone structure of the jaw.

Periodontal disease can begin to develop when salivary glands produce less saliva if an animal does not have to chew its diet. Saliva has several roles in reducing the formation of plaque including roles as an antimicrobial, a lubricant, buffering (maintaining normal pH) and, remineralization of teeth. Numerous research findings - starting with Egelberg in 1965 - have associated ground meat diets for carnivores with the formation of dental plaque and calculus especially when compared to animals fed whole prey and/or slab meat diets. The formation of plaque is a problem because it becomes an excellent growth substrate for bacteria. Plaque also eventually forms calculi (mineralized plaque) at the gum line. Calculi cause inflammation and allows further growth of bacteria that penetrates the gum line and continues the tooth decay process within the gums. The formation of calculi can also loosen teeth as it grows into the gum.

Dry, commercial diets are often advertised as a solution to the formation of plaque on the basis that the dry, gritty nature of the pellet and/or the form of the pellet removes plaque when the animal chews the pellet. There are two problems when applying this concept to captive, wild carnivore species. The first problem is that carnivore species do not chew their food. Carnivorous species rip and tear chunks of food from prey or slabs of meat. The second problem is the level of carbohydrates in dry, commercial feeds for carnivores. Dry, commercial diets for carnivores are not appropriate for captive, wild carnivores because they are too high in carbohydrates. Carnivores should have dietary carbohydrate levels < 1.5% (Dierenfeld et al, 1994).

A lack of chewing can also promote teeth loss. For example, if bite-load and tooth wear is not sufficient, teeth can shift forwards or backwards and/or can begin to rise from the gums. This changes the height and alignment of the teeth, further decreasing the bite-load and tooth wear and resulting in exposed teeth roots, decay and loss of the teeth.

Trauma to the bone structure of the jaw can result from diets that do not require chewing. This trauma can also lead to focal osteomyelitis and can progress to osteonecrosis of the jaw and facial bones. Research by Marker and Dickman (2004) on cheetahs fed processed foods that do not require chewing supported diet as a cause for the development of "palatine erosion". Palatine (bone that is part of the hard palate) erosion occurs

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when the lower carnassial teeth (first lower molar) do not properly close together (occlude) with the upper carnassial (last upper premolar). Instead of the carnassial teeth aligning (occluding) when the upper and lower jaw is brought together, the lack of occlusion causes the carnassial teeth to hit against the palate. Repeated trauma to the palate penetrates the mucosa and the bone allowing secondary pathological processes such as osteomyelitis and osteonecrosis.

Gastrointestinal. Our discussion on chewing opportunities for carnivorous species should include the effect on the gastrointestinal (GIT) system. Ground meat diets are highly digestible, meaning the ingredients are designed for optimum digestion and absorption without waste. However, the wild diets of most carnivores include ingestion of carcass components that are not digestible. In other words, whole carcass diets provide bulk in a carnivore's diet (skin, feathers, hair, bone, etc.) that is not provided by a ground meat diet. Therefore, some carnivores may develop gastrointestinal problems such as diarrhea and constipation that could be related to a diet of only ground meat. Often, the problem can be resolved by adding whole carcasses, or parts of carcasses, to the diet. Adding fiber to a carnivore diet is not the solution. Fiber is a carbohydrate, plant matter, and the current recommendation for dietary carbohydrate level in carnivore diets is < 1.5% (Dierenfeld et al, 1994).

Lack of Occupation. There has been much credible research on the nutrient appropriateness of ground meat diets for carnivores. However, these foods are consumed rapidly by an animal meaning food enrichment items such as bones or other items must be used to provide "occupation" (something to do) and contribute to dental health. The process of "occupation" may also contribute to the psychological of health of an animal. Food that must be manipulated in some manner (caught, ripped, shredded, removal of shells, etc.) provides occupation and, as an activity, could help to reduce stress and also help maintain healthy body weights

Inappropriate use of Horsemeat Prepared Diets. It is common for commercial, ground horsemeat diets developed for carnivores to be fed to any species that are classed as a carnivore. Using horsemeat diets for all carnivores may be inappropriate based on the natural prey selection in wild feeding ecology. For example, ground horsemeat diets are fed to otter species and otters are piscivores. Birds of prey species that normally eat bird prey, rodents and rabbits are fed ground horsemeat. Insectivorous species such as meerkats are also fed ground horsemeat. These are all examples of species that have physiologies evolved to do best on prey diets that provide a very different spectrum of nutrients as that provided in ground horsemeat diets. Most wild carnivorous species have evolved on diets that do not include and/or are limited in red meat (horsemeat); are abundant in white meats (fish, birds, rodents); and, include prey with very specific fatty acid spectrums quite different from that in horsemeat.

Dietary Fat Level. Ground meat diets, especially those based on horsemeat, may be very low in fat compared to current recommendations for captive carnivores. The average fat content of horsemeat is 4% to 6% and the dietary fat level of commercial horsemeat diets ranges from 7% to 15%. The current dietary fat recommendation for captive carnivores averages at 12% (Dierenfeld et al, 1994),

Captive diets are not the only influence on pathology in captive carnivores. Current evidence exists that tells us that animals kept and bred in captivity have slightly different behavioral and morphological traits than wild conspecifics. These differences could be partly due to selection (breeding), environment and/or diet. Breeding of animals by zoological institutions can be based on achieving a certain phenotype (observable physiology) or temperament and such selection can shape a species' physiology and behavior in numerous ways divergent from wild conspecifics. One must consider that those animals that can (do) survive in a zoological institution will be the animals that function best in that type of environment and the traits of those animals will be retained within the captive population of that species.

However, we have seen in the data presented in this article that the diets of zoological institutions affect the health of our animals and can create change in an animal's behavior and physiology in positive and negative ways.

The purpose of this material is not to criticize commercial diets for carnivorous species in captivity. The purpose is to remind us that we must respect the physiology of an animal. If we respect the physiology of an animal, then we understand how that physiology has developed over thousands of years to best promote the survival of a species. Therefore, in captivity, we must provide diets that respect physiology and provides for all aspect of nutrition including nutrients, chewing, digestion and speciated behaviors.

This Issue: Nutrition Problem

Fallen Leaves as Forage

The "problem" I selected for for this issue is not a problem, but a timely question. As we go into the fall season, fresh browse becomes scarce and fallen, dessicated leaves become plentiful. I am often asked if fallen leaves can be used as browse for herbivorous species in captivity. Often, the question is based on the wild feeding ecology of many herbivores - especially in North America - that will dig up fallen leaves from under snow and use them as food.

Reduced nutrients, low digestibility. Fallen leaves, of many plant species, are used as survival foods for many North American browsing species in the winter. However, the key word is "survival" meaning fallen leaves provide an extremely low density of nutrients during seasons when foods are scarce. For example, the loss of protein (nitrogen) in fallen leaves averages at more than 64.0% in willow (*Salix sp*) leaves and more than 74.0% in birch (*Betula sp*). In addition to a reduction in nutrients, the digestibility of fallen leaves is very low. Low digestibility means the reduction in nutrients is further reduced because the animal cannot digest a large proportion of the food. For example, even in in caribou and moose, the digestibility of fallen leaves is only approximately 20.0% for fallen birch leaves and 30.0% for fallen willow leaves.

Low in energy. Senescent (fallen) leaves also are very low in energy (kilocalories; calories). Therefore, in addition to minimal nutrients and low digestibility, fallen leaves do not supply significant energy. The lack of energy results from the process of leaf senescence. During the process of leaf senescence – before the leaf drops to the ground - the cell contents of the leaf cells are absorbed by the plant. This reduces the nutrient content, the energy content, and it also reduces the soluble fiber. The loss of soluble fiber will alter the ratio of soluble to insoluble fiber leaving the insoluble fiber. Insoluble fiber does have an important role in the diets of herbivores and omnivores, but foods that provide only insoluble fiber will have an extremely low digestibility.

Silica. Fallen leaves are very high in silica and silica can cause excessive tooth wear. Leaves accumulate silica as they age and senescent leaves have the highest level of silica.

Contaminants. Fallen leaves are also a source of foreign, indigestible contaminants such as twigs. dirt, sand and stones. As food contaminants, they can irritate the gastrointestinal tract, form phytobezoars and can cause excessive tooth wear.

Can fallen leaves be used as forage for herbivorus and omnivorous species in captivity? They should not. Fallen leaves are very low in nutrients, energy and digestibility. These factors mean that fallen leaves are a very poor food source. In addition, fallen leaves can cause excessive teeth wear, irritate the gastrointestinal tract and form phytobezoars.

Problems Wanted!!

Each issue of "Wildlife Nutrition" will present and discuss a specific dietary challenge submitted by readers. Any aspect of the nutrition of captive wildlife will be considered for publication. The dietary challenge may be a question, situation or nutritional pathology. Questions re: body condition must be accompanied with a photo. The identity of the submitting individual and/or their organization will be confidential. Please submit to:

Wildlife Nutrition
info@caza-narg.ca

The Cost of Nutritional Pathology

It has been estimated that more than 40% to 70% (dependent on species and/or disease process) of pathology in zoo animals can be related to inappropriate nutrition (either as primary or secondary disease). Often, the problem is not identified until post-mortem. When nutritional pathology is identified in living animals, the provision of nutrition services to zoo animals becomes reactive to a disease process rather than preventive. One of the mandates of CAZA-NARG, and our work of over 10 years, is to educate and provide information to prevent the development of nutritional pathology.

The Costs of Nutritional Pathology

Cost has to be a factor in any diet formulation, but we often forget that inappropriate diets that cause nutritional pathologies cost zoological institutions thousands of dollars yearly in veterinary costs, loss of breeding opportunities and loss of animals. I think we need to think and talk about those costs and I will do this by a fictional case study in Type II diabetes in rhesus monkeys.

Type II diabetes is a good example to use because it affects so many species in our care. Bird species, canines, elephants, felines, fox, hoof stock, kinkajou, primates, raccoon and rodents are only a few examples of the captive species affected by Type II diabetes.

Factors in the Cost of Type II Diabetes

If you have a diabetic rhesus monkey, you will need these resources to treat your diabetic monkey:

- Veterinarian
- Vet tech
- Daily blood tests
- Daily urine tests
- Training of the animal for insulin shot
- Daily insulin dose (or, doses)
- Syringes
- Test strips

Each of these factors represents a cost to your zoological institution or organization including training of the animal to cooperate with the procedure of administering the insulin dose. For example, staff hours will be needed to train the animal or you may need to hire a behaviourist to train your staff and the animal.

Potential Cost of Resources

Let's calculate the costs of treating a diabetic rhesus monkey for Type II diabetes by adding the costs of each factor other than training costs. Prices may vary depending on location, veterinarian contracts (consulting veterinarian versus staff veterinarian) and costs for supplies.

Staff Veterinarian:	$50-$100 per day
Staff Vet tech:	$25-$50 per day
Daily Test Strips (6-8):	$ 8-$11
2 Syringes per Day:	$ 1.20 (u-100)
2 Needles per Day:	$ 0.30 (28 gauge)
2 Insulin Doses per Day:	$18 - $225 (20-250 units daily)

Total Medical Cost per Day: $102.50 - $387.50

These costs appear reasonable. However, this animal will need treatment every day. Let's calculate the costs of treating a diabetic rhesus monkey for Type II diabetes ***for one year***:

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Veterinary:	$18,250 - $36,500
Vet Tech:	$ 9,125 - $18,250
Test Strips:	$ 2,920 - $4,015
Syringes:	$ 438
Needles:	$ 109.50
Insulin:	$ 6,570 - $82,125

Total Medical Cost per Year, One Diabetic Animal: $37,412.50 - $141,437.50

The yearly cost of treating a diabetic rhesus monkey for Type II diabetes now is a considerable sum of money: $37,412.50 - $141,437.50.

However, one must consider that such a rhesus monkey is probably housed in an exhibit with conspecifics and these conspecifics are fed the same diet that caused the Type II diabetes in our original rhesus monkey. Therefore, it is likely that most – if not all – the animals in the exhibit may develop Type II diabetes.

Let's say four animals in the rhesus monkey group develop Type II diabetes. This means you now have the medical costs to treat four animals for Type II diabetes and that cost will be approximately **$149,650 - $565,750 per year.** This is a considerable amount of money and we have not yet calculated and added the cost of the original diet that caused the disease.

In addition to the medical cost of Type II diabetes, there is also loss of quality of life for the animal. This loss of quality of life cannot be quantified and is produced by obesity and Type II diabetes symptoms such as dry, itchy skin (hide); fatigue; immune dysfunction; impaired glucose tolerance; ketoacidosis (acidic blood pH); numbness and neuralgia; polydipsia; polyuria; kidney failure; and, vision loss.

What is the alternative?

There are numerous options for either prevention or disease management of Type II diabetes. I like to emphasize prevention, meaning using these management techniques before a disease process begins.

1. **Energy balance**. Excess dietary energy is a factor in Type II diabetes. Formulating diets based on the energy (kilocalorie; calorie) needs of the animal and monitoring weight and body condition to ensure energy needs are met.
2. **Appropriate Energy.** An inappropriate form of energy is a factor in Type II diabetes and the appropriate form of energy is different depending on the species. For example, carnivorous species use protein and fat for energy and omnivorous species use carbohydrates and fat for energy.
3. **Dietary Fat.** Diets high in fat and high in saturated fat are a factor in Type II diabetes. Captive diets must provide the appropriate levels and types (saturated versus unsaturated) of fat.
4. **Dietary Carbohydrates.** Inappropriate dietary carbohydrates and/or an excess of dietary carbohydrates are a factor in Type II diabetes. Diets must reduce and/or eliminate simple carbohydrates (sugars).
5. **Balanced rations.** Rations that do not provide a balance between protein, fat and carbohydrates are a factor in the development of Type II diabetes. Metabolic processes need a balance of all types of nutrients at the same time to avoid such things as repeated insulin spikes that ultimately cause insulin insensitivity. Diets must provide a balanced complement of protein, fat and carbohydrates.

Additional Costs

Inappropriate diets and/or supplementation have costs other than those related to the actual disease process. In general, a minimum of 10% of food costs (includes all activities from purchase to food presentation) can be saved by professional diet formulation, informed feed purchase and, appropriate feed delivery systems. For example a zoo with food budget of $700,000 could save at least $70,000 per year. The 10% savings does not include any savings resulting from a decrease in veterinary hours, staffing costs, the cost of treatment resources and/or animal loss due to nutrition-related health problems.

When diets and dietary supplementation are appropriate, the incidence of nutritional pathology decreases, we save time and money and, we can expect to see an increase in animal health and welfare. An increase in animal health and welfare is directly related to an increase in job satisfaction by you - the zoo professional - because an increase in job satisfaction is a natural outcome of providing appropriate nutrition and observing healthy animals.

Insights: Using Food to Manage Behaviour and Provide Environmental Enrichment

Environmental enrichment (food enrichment) provides many benefits for both staff and the animals in their care. For the staff, the interaction and design of enrichment facilitates relationships, enhances training opportunities, fosters cooperative behaviours and provides close proximity for health checks. Environmental and food enrichment can positively affect behaviour by encouraging the display of natural behaviours; reduce stereotypical behaviours; reduce self-mutilation or mutilation of conspecifics; reduce aggressive behaviour; and, it can be a factor in the reduction of stress and fear. Environmental and food enrichment can also have physiological benefits by increasing activity, reducing the plasma cortisol level and it can increase immune function.

When providing environmental and food enrichment, one must ensure that the animal is not harmed. Safety considerations when designing and selecting enrichment tools include (Young, 2003):

1. Check for sharp edges that may result in cuts and abrasions.
2. Check that the animal, or a part of the animal, cannot be trapped.
3. Can the animal break, chew or dismantle the enrichment tool? If so, would fragments hurt the animal or would parts of the device cause harm?
4. Are non-toxic materials used?
5. Could the enrichment be used as a weapon against conspecifics or humans?
6. Can the enrichment damage the exhibit (enclosure)?
7. Could the animal use the enrichment to escape?

When considering the use of food to manage behaviour and/or provide environmental (food) enrichment, we must consider several factors. Among these factors are:

1. The food must be part of a balanced diet regimen.
2. The food must be appropriate for the species.
3. The food portion must be appropriate for the size of the animal.
4. Small food amounts works just as well as big food amounts.
5. Food does not have to "special".
6. Keep the foods "Close to the Earth". In other words, remove the processed treats (cookies, breads, granola bars, etc.).
7. It does not always have to be about food.

In addition, it is important from dietary and budgetary perspectives to use food in a manner that will provide the most nutrition for the least cost. For example, food used to manage behaviour or provide enrichment must be included as part of the daily diet. This means the food must provide nutrition and it must not provide energy (kilocalories; calories) beyond maintenance energy needs. A good "rule" is to reserve 10% of the prescribed daily energy (kilocalories; calories) to be used to manage behaviour or as food enrichment.

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Following are a series of examples on the use of food and non-food items to manage behaviour and provide environmental (food) enrichments.

Environmental (Food) Enrichment by Nutritional Niche

Carnivorous Species
- Live food (fish, brine shrimp, crustaceans, insects)
- Ice blocks containing food
- Stiff gelatin containing food
- Whole eggs (limited)
- Hiding food
- Transfer potted plants in and out of the exhibit
- Novel odours
- Substrates (snow, sand, hay, etc.)
- Frozen eyeballs, intestines, blood
- Skins, hides (non-processed)
- Tails, ears, hooves
- Marrow bones (bones with marrow include femur (thigh), ball joints (articulators), ribs, tibia (shin)

Omnivorous Species
- Whole fruit and vegetables (limit fruit)
- Tree branches
- Turkey/chicken heads or necks
- Plants and grasses
- Spices
- Herbs (best if fresh): basil, chives, cilantro, dill, thyme

Herbivorous Species
- Browse (listed below)
- Herbs (best if fresh): basil, chives, cilantro, dill, thyme
- Spices
- Fresh grasses for grazers
- Edible flowers (listed below)

Browse for Enrichment
- American Beech (*Fagus granifolia*)
- Alder (*Alnus sp*)
- Crabapple (*Malus sp*)
- Forsythia (*Forsythia sp*)
- Grape (*Vitis vinifera*)
- Hibiscus (*Hibiscus rosa*)
- Maple (*Acer sp*)
- White Poplar (*Populus alba*)
- Willow (*Salix sp*)

Edible Flowers
- Dandelions
- Chrysanthemums
- Flowers of herbs
- Hibiscus
- Impatiens
- Marigolds
- Nasturium
- Pansies

Environmental (Food) Enrichment by Species

Avians
- Herbs
- Spices
- Live prey (insects)
- Organic piles for foraging
- "Toys"
- Colours
- Plants
- Plants
- Suspend food
- Feedign sticks
- Substrates

Bat Species
- Variety of feeding roosts
- Substrates
- Suspended browse, twigs
- Live plants
- Shallow pool of running water
- Spices
- Music
- Insects

Primate Species
- Sugar free gum
- Browse (bamboo, willow, alfalfa)
- Whole vegetables
- Herbs
- Spices
- Edible flowers

Reptiles and Amphibians
- Live prey (insects)
- Substrates
- Plants (mosses, herbs, grasses)
- "Rain"
- Rock arrangements
- Shallow water with waterfall
- Edible flowers

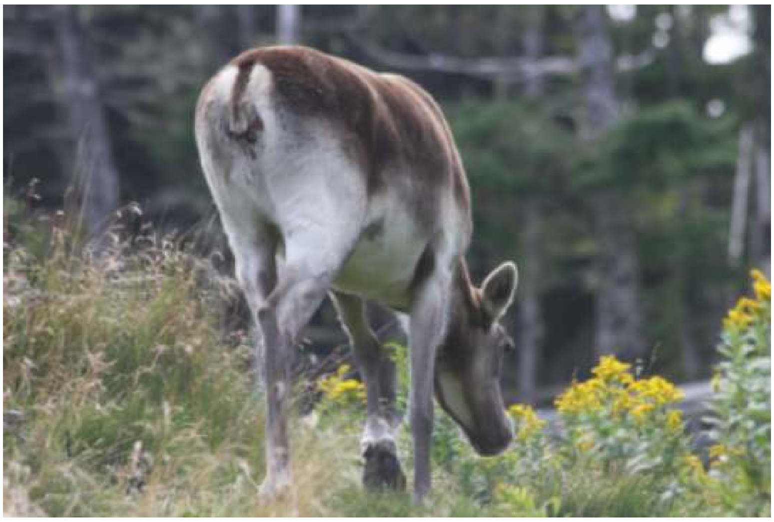
This Issue: Pictures and Comments

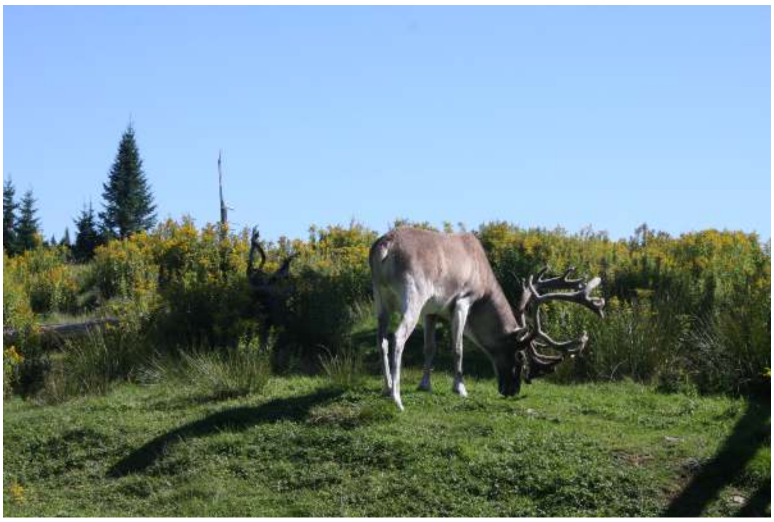
In this issue, I have the pleasure of presenting several pictures of caribou and moose held at the Salmonier Nature Park in Holyrood, Newfoundland. These photographs depict excellent body condition in wild, North American ungulates in captivity.

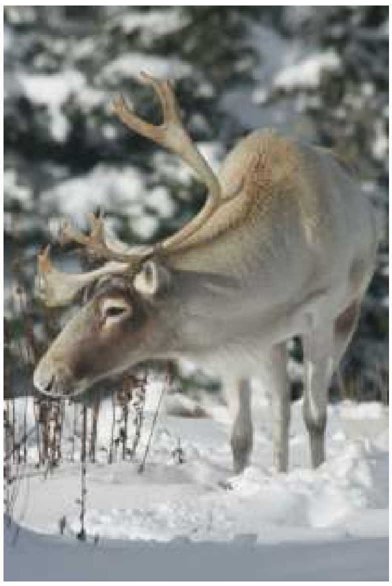
First, note the quality of hide on these animals. These pictures show the animals in different seasons, yet their hides are smooth, glossy and without blemish. Second, examine their overall body condition and musculature. These animals are rounded, there is obvious flesh over bone without sharp edges on their backs, neck or hips. The ribs cannot be seen. These animals have an optimum amount of muscle and fat as depicted in slightly rounded sides and full, firm hips. Their legs look solid and have obvious musculature. The antlers of the male caribou are without deformity.

The female and male caribou shown in these photos arrived at Salmonier Nature Park as calves in October, 2008. Their calf was born May 14, 2012.

<u>Photo Credits:</u> Melanie Whalen, Newfoundland Wildlife Division, Salmonier Nature Park, Holyrood, NL. melaniewhalen@gov.nl.ca







This Issue: Picture and Comments (cont'd)

This female moose held at the Salmonier Nature Park is 9 years old. She arrived at Salmonier Nature Park as a calf in 2003.

<u>Photo Credits:</u> Melanie Whalen, Newfoundland Wildlife Division, Salmonier Nature Park, Holyrood, NL. melaniewhalen@gov.nl.ca