Wildlife Nutrition

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

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In Support of Captive Wildlife Nutrition . . . .

Since the creation of CAZA-NARG in 2000, one of the CAZA-NARG mandates has been the provision of wildlife nutrition education to those professionals with responsibility for any aspect of the diet provision for captive wildlife. This first issue of "Wildlife Nutrition" is a continuation of that work. All issues, however, will be designed to educate, yet provide recommended practices that each of you can use on a daily basis.

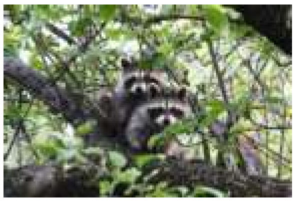
Why? Historically, the incidence of nutritional pathology in zoological institutions and wildlife organizations has been epidemic. For example, research estimates that as much as 70% of the pathology in captive wildlife is directly or indirectly related to inappropriate captive nutrition. Most of the nutritional pathology is not diagnosed until post-mortem (autopsy).

Some of the prevalent, multi-species nutritional pathologies in zoological institutions include cardiac disease, fatty liver (hepatic lipidosis), immune dysfunction, iron storage disease (hemosiderosis, hemochromatosis), metabolic bone disease (MBD), Type II diabetes and, vitamin and mineral imbalances (excesses and deficiencies). The development of these nutritional pathologies can be attributed to several common captive diet problems that include inappropriate and/or excessive dietary fat; inappropriate dietary proteins (amino acids) and/or amounts or dietary protein; and, inappropriate and (often) excessive dietary carbohydrates.

How? Providing appropriate diets to captive wildlife can only be accomplished by using wild feeding ecology to formulate and deliver diets. Yes, we do lack information on many species. However – increasingly - we have reliable data from field research that can be applied to the captive environment. This issue will provide some focus on wild feeding ecology in addition to other topics that should be useful for you.

Thank you for your subscription to "Wildlife Nutrition"!

Deb McWilliams



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In This Issue . . .

Wild Feeding Ecology: What is it?

The only reliable way to provide appropriate diets to captive wildlife is to formulate diets based on a species wild feeding ecology. However, not everyone has the same understanding of the term "wild feeding ecology".

What is "wild feeding ecology"? Wild feeding ecology is based on four main factors: evolution, environment, physiology and behaviour. The essential premise is that the physiology and behaviour of a species has evolved to best survive in an environment (foods, weather, etc) over (in most cases) hundreds of thousands of years.

While there is some plasticity to both physiology and behaviour, there are limits. For example, one could view the ability of a species to adapt to different foods and environments as a spectrum. The spectrum provides a range of conditions in which the species can thrive with the middle of the spectrum being the optimum condition(s) and the two extreme ends as the limit(s). Outside of that spectrum, the species will develop disease processes related to diet or environment and/or will not survive. Therefore, to provide the best possible diet in captivity, we must respect that captivity does not change the spectrum of conditions in which a species can thrive and survive. Specifically, when formulating diets for captive wildlife, we must respect the gastrointestinal system of the species and the wild feeding ecology in relation to the form and function of the diets we provide.

What "wild feeding ecology" does not mean in captivity. Formulating and providing diets in captivity to wildlife <u>does not</u> mean creating an exact duplication of a wild diet in captivity.

What "wild feeding ecology" does mean. Formulating and providing diets in captivity for wildlife <u>does</u> mean we must provide our best approximation of a wild diet in nutrients and often in form. This requires not only an understanding of the foods eaten in the wild, but also an understanding of the physiology and behaviour of the species. Using principles of wild feeding ecology, let us look at some examples from three nutritional niches:

1. **Carnivore:** Lynx do not ***need*** to eat snowshoe hare. Snowshoe hare are a common prey item for wild lynx, but it is not a necessity if other prey is available in captivity. However, lynx are <u>**obligate carnivores**</u> meaning their physiology requires a meat (animal) diet and they cannot thrive and survive on diets that include plant foods.
2. **Omnivore:** Black bears do not ***need*** to eat blueberries (wild or cultivated). Black bears will eat wild blueberries on a seasonal basis if they are available. However, blueberries are not an essential food item in captivity for black bears. Black bears are omnivores and thrive and survive best on diets that include a variety of foods (animal and plant foods). They cannot thrive and survive if they are fed a carnivore diet or a vegetarian diet.
3. **Herbivore:** Giraffe do not ***need*** to eat acacia leaves. The giraffe is a herbivore and does eat the leaves of acacia trees as a preferential food in the wild. Similar to other herbivorous species, the giraffe must obtain most of its nutrients via a symbiotic relationship with healthy gut organisms. Forage supports those gut microorganisms. The captive diet of the giraffe must provide plant foods (forage) with the closest approximation in nutrients and fibres that a giraffe would eat in the wild to provide nutrients to the giraffe ***and*** the gut microorganisms. If other plant foods are available that provide equitable nutrients, then acacia leaves are not an essential food item in captivity. The substitute foods must also be provided in a manner that reflects the wild feeding ecology of giraffes such as eating from trees and using their prehensile tongue to grasp and pull food into their mouth.

What is wild feeding ecology? Wild feeding ecology – in captivity – is the formulation and provision of diets to captive wildlife with an understanding and respect of the evolutionary process and environment that shaped the species physiology and behaviour.

Carnivore Nutrition: Predator Diets

Often, the word "carnivore" is used to denote a mammal that eats meat. For example, most folks typically think of large cats (lions, tigers, panthers, etc). However, when formulating diets, a carnivore is any species that is a predator and requires either a meat (meat-eater), insect (insectivore) or fish (piscivore) diet. In general, carnivorous species obtain all the nutrients they require if they eat whole carcasses whether that carcass is a mammal, a bird, a fish or an insect. Calcium, for example, is supplied by exo- or endoskeletons and other nutrients are found in flesh, viscera, hair, hide, fur and feathers.

Carnivorous species have some physiological similarities such as only one stomach (monogastric) and a short gastrointestinal tract (GIT). The short GIT has evolved from a diet of highly digestible protein diets. Protein, especially meat, is digested and absorbed thoroughly despite a short GIT and rapid gastric transit time .

Although there is some dietary flexibility in most species, carnivores are also classified as a) animal tissue eater (meat-eater) b) insectivore or c) piscivore:

1. **Animal Tissue (Meat-eater):** Meat-eaters usually eat vertebrate prey. Carnivore species classed as meat-eaters include aardwolf, badger, canids, felids, fox, hyena, marten, meerkat, mink, mongoose, polar bear and the Tasmanian devil. Species classed as meat-eaters are obligate carnivores.
2. **Insectivores:** Insectivores usually eat invertebrate prey. Carnivore species classed as insectivores include many bat species, hedgehogs, moles, primates (some species), rodents (some species), tamandua and tenrecs. However, many insectivores have a dietary flexibility and will include other prey or foods in their diet depending on season and food availability. Therefore, one might assume that insectivorous species are not obligate insectivores, but they are obligate carnivores. Increasingly, however, research into the wild feeding ecology of insectivores indicates that we may have to re-think this assumption. When evaluating research evidence, it appears that most insectivorous species are both obligate insectivores and obligate carnivores because captive insectivorous species fed mostly vertebrate diets often develop nutritional pathologies. For example, insectivores fed red meat diets often develop fatty liver and kidney stones.
3. **Piscivores:** Piscivores, in general, eat both vertebrate and invertebrate aquatic prey. Examples of carnivore species classed as piscivores include the fishing cat, giant otter shrew, otters (river and sea), penguins, Rickett's big-footed bat, seals, seals, sea lion, walrus and whale. Providing the appropriate type of dietary fat to piscivores is an issue in captive care. The dietary lipids in fish are high in unsaturated fats. Terrestrial prey species are high in saturated fats and piscivores fed diets of terrestrial prey will develop nutritional pathology. The unsaturated fatty acids in aquatic prey species provide a fatty acid spectrum that is also different from terrestrial prey species. The fatty acids vary depending on the environment and life stage of the fish prey. As an example for environment, oily fish species (coldwater fish, marine fish) store fat in their muscle. Fish from freshwater or warmer bodies of water are "nonoily fish" meaning fat is stored in the liver (not in muscle). If a piscivore is fed only eviscerated, freshwater fish, then the fish carcass will lack some necessary fatty acids. (Recommended practice is to feed whole fish carcass (marine or freshwater with the viscera intact). As an example of life stage, the fat content of a fish carcass can vary from 1% (after spawning) to 20% (before spawning). There are other fatty acid differences in fish prey. Freshwater fish contain twice as much capric acid (C10:0; decanoic acid) and C18 fatty acids (e.g., linoleic) but, less than half the quantity of C20:4 (arachidonic) and only one-seventh the quantity of behenic acid (C22:0; docosanoic acid) fatty acids than marine fish. For those predators that eat squid, caproic acid (C6:0; hexanoic acid) is important because squid has as much as two to four times more caproic acid relative to other prey items. Timnodonic acid (C20:5; 5,8,11,14,17-eicosapentaenoic acid - EPA) and docosahexaenoic acid (C22:6; 4,7,10,13,16,19-docosahexaenoic acid - DHA) are high in krill and herring. Therefore, species evolved on herring and krill diets will likely require high levels of these fatty acids in their diets. This data infers that the dietary fatty acid composition fed to freshwater piscivores should differ than that fed to marine piscivores.

Note: The recommended practice when feeding fish is to supplement each animal daily with a minimum thiamin 30 mg/kg fish as fed and vitamin E 100 IU/kg fish as fed.

Carnivore Nutrition: Obligate Carnivores

It is important to understand that a species classed as a carnivore is an "obligate carnivore". Obligate carnivores have physiologies that can only function effectively on a prey diet. For example, a species is classed as an obligate carnivore if their physiology requires:

Protein and Fat for Energy. Carnivore species use protein and fat for energy and not carbohydrates (plant sources of food). Obligate carnivores cannot digest carbohydrates (especially starches), but they do need a source of dietary roughage. Carnivores obtain dietary roughage from eating viscera (e.g., stomach and/or cecum contents) and other carcass components such as bone, fur, feathers and hide. One must also be aware of the carbohydrates available in commercial foods for felines. Commercial foods for domesticated felines are designed for a species that has been purpose-bred to survive on higher levels of dietary carbohydrates than wild carnivores. For example, commercial feline foods contain less than $< 5\%$ carbohydrates, but the current recommendation for captive carnivores is $< 1.5\%$ dietary carbohydrates (Dierenfeld et al, 1994). Carnivores fed diets too high in carbohydrates will lose muscle mass. In addition to the dietary carbohydrate level, some types of carbohydrate may not be suitable for captive, wild carnivores. For example, rice products in foods for cats can reduce serum concentration of taurine (Stratton-Phelps et al, 2002).

Essential Amino Acids. Carnivores require dietary sources of over ten amino acids especially arginine and taurine. Arginine is important for growth and the prevention of hyperammoneaemia (excess ammonia levels in the blood). Taurine deficiencies can result in abortion, cardiomyopathy, fetal resorption, retinal atrophy, and stillbirth. Neonates that are taurine deficient have low birth weights, low survival rates and slow growth rates (Sturman et al, 1986; Sturman 1991; Sturman and Messing, 1991; Sturman and Messing 1992). The taurine content in commercial milk replacers is too low for neonate felids (Hedberg et al, 2007) and probably for most carnivores. At this time, we also know that dietary levels of taurine do not always predict metabolic levels of taurine (plasma levels) and this varies by species and by individuals within species (Hedberg et al, 2007). For felines, plasma and whole blood levels of taurine are both needed to accurately assess taurine status (Pacioretty et al, 2001).

Protein for Normal Blood Glucose Levels. The normal blood glucose levels of carnivores are maintained by protein (amino acids) in a process called gluconeogenesis. Gluconeogeneisis is the synthesis of glucose from molecules other than carbohydrates. For example, methionine and cystine (cysteine) are gluconeogenic amino acids for carnivore species and are abundant in animal tissue – not plant tissue.

Essential Fatty Acids. The essential fatty acids required by carnivorous species are similar, but species will require different ratios dependant on their nutritional niche. For meat-eating species, the fatty acids linoleic, linolenic, arachidonic and eicosotrienoic are particularly important dietary essential fatty acids and these fatty acids are best provided in meat-based diets that include animal (saturated) fat. However, the important essential fatty acids for insectivores include (in addition to other omega-3 fatty acids) omega-3 (linolenic acid) at 1.1 to 2.2 g/kg per insect and omega-6 (linoleic acid) at 3.5 to 49.0 g/kg per insect Finke (2002). Those species that are piscivores vary in their dietary requirement for fatty acids depending if they eat cold-water or warm water aquatic prey (see #3, previous page).

Vitamin A. A dietary source of vitamin A (retinol) is necessary for carnivores and is usually available in viscera (e.g., liver).

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

Weighing Animals

Weighing animals on a regular basis and recording those weights are the best way to ensure that an animal does not become underweight or obese. The second best method is to use a visual "body condition score" that is designed for a species. Visual health checks can be also incorporated into either method.

I am often told that major obstacles to weighing animals and keeping weight records are time and equipment. These obstacles can be very real. In some animal groups, it is impossible to weigh each animal. Some species are very large and specialized (expensive) equipment is necessary to obtain a weight.

However, there is a simple way to incorporate weight evaluations into our work responsibilities. Many of the visual "body condition score" systems are very useful to monitor the weight of an animal and they do not require much time, they do not require equipment and, the time needed to train staff is minimal. A pre-made chart that allows writing down the date and the body condition score is an effective and inexpensive recording system. Such a method truly is cost effective when one considers the health benefits of appropriate weights for the animals in your care.

Weight changes can also alert us to health problems and tracking the body condition of an animal has many advantages:

Avoid obesity. A weight gain allows us to change the diet to avoid obesity. It is much easier for an animal to lose a small amount of weight rather than a large amount of weight. In addition, we know obesity is associated with many health problems such as cancer, cardiac disease, diabetes, hepatic lipidosis (fatty liver), hypertension, neurodegenerative disease, orthopedic disease and, reproductive disorders. Regular scoring also assists in monitoring the dynamics within animal groups. For example, is a dominant animal eating most of the food? Is a subordinate animal not getting enough food?

Diagnose a pregnancy. A weight gain may alert us to an unsuspected pregnancy.

Identify potential illness. A weight loss may alert us to investigate the animal's health to explore the possibility of illness such as cancer, diabetes, infection or, parasites.

Aid in diet formulation. The weight of an animal can be used to reliably provide the correct amount of a diet. For example, there are equations available that can estimate the daily kilocalorie requirements of an animal based on their weight. These equations suggest an approximate daily kilocalorie that can be modified (more or less) based on the changing needs (e.g., body condition) of an animal.

Provide adequate nourishment for growth. Monitoring weight and body condition is essential to ensure healthy weight gain in neonates and juveniles and to modify the diet as the animal grows.

Prescribe medications and supplements accurately. The weight of an animal is often necessary to accurately provide supplements and medications.

How often should you weigh or body score an animal? It is recommended that you obtain a **monthly** weight or body condition score for your animals. If this schedule is not possible, then the maximum time between obtaining weights or a body condition score is once every two or three months.

Your Photos

We invite wildlife professionals to submit photos of animals in their care. One or more photos will be highlighted in each edition of "Wildlife Nutrition". The identity of the photographer and the institution or organization where the animal resides will be displayed with each photo. All photos must be of captive wildlife in good health and excellent physical condition. Please submit to:

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Reptiles, Nutrition and Ultraviolet (UV) Light

I frequently get asked if captive reptile species need a source of ultraviolet (UVB) light. UVB light is electromagnetic radiation with wavelengths of 280-320 nanometres (nm) and it is found in light waves emitted by the sun. The moon reflects light from the sun, therefore moonlight does have UVB light, but the intensity is much less than sunlight. For example, only 13.6% of the sun light that reaches the moon is reflected to earth (R.L. McNish, The Royal Astronomical Society of Canada, www.calgary.rasc.ca).

We now have considerable research evidence that UVB light is an essential environmental factor for the cutaneous production of vitamin D_3 in captive reptile species. This cutaneous process is both UVB light and heat dependent. A brief explanation of this complex process is that pro-vitamin D (7-dehydrocholesterol) in the skin of the animal is thermally (with heat) converted into Vitamin D_3. Vitamin D_3 is essential for calcium metabolism and bone health. Dietary sources of vitamin D_3 and/or oral supplements are not sufficient (Oonincx et al, 2010). A source of UVB light is also necessary for other physiological processes and it is an important factor in the control of skin parasites and bacteria.

Since UVB light and heat is necessary for the cutaneous production of vitamin D_3 (and heat is also necessary for other physiological functions), captive reptiles need both a UVB source and a heat source. In the past, products that offered heat and UVB light had to be provided separately. Now, there are some excellent products that offer both UVB light and heat. One of the best sources for research and information on UVB light and reptiles can be found at **www.UVguide.co.uk**, a website that provides free and specific information.

Some recommended protocols to provide the appropriate UVB light and heat to captive reptiles include:

1. **Separate heat and UV light sources.** If you use a separate source for heat and a separate source for UVB light, the two sources must be hung together (radiate on the same spot). This is because reptiles will choose a heat source over a UVB light source. If you combine the UVB light with heat, the animal will seek the heat but also get UVB light. Both the UVB light and the heat lamp should be on a timer. The UVB light should be on only 1 to 5 hours per day (see #3). The heat lamp should be on to match a typical day length according to the appropriate season (e.g., shorter in winter, longer in summer).
2. **Combination UVB light/heat lamps**. If you use a combination UVB light/heat lamp, it should be on a timer and/or be operated manually to provide only 1 to 5 hours per day (see #3). A separate heat lamp should be provided to continue offering a heat source (without UVB light) to the animal for the remainder of the day cycle.
3. **Appropriate UVB exposure.** Too much UVB light can be as much of a problem as too little UVB light. Therefore, the UVB light should be operated only 1 to 5 hours per day. The operation time will vary according to the speciated needs of the animal based on the wild environment from which it evolved. The operation time will also vary according to the UVB light specification. For example, if the UVB light specification is $10uw.cm^2$, then 1 hour is sufficient exposure for the animal to produce vitamin D. If the UVB light specification is $1.1uw.cm^2$, then 5 hours is needed for the animal to produce vitamin D.
4. **When to provide UVB.** Most species will reliably bask when a heat lamp first comes on. Therefore, it is important to have “UVB on” for this first basking period to ensure adequate UVB exposure.
5. **Nocturnal reptiles and UVB.** Although nocturnal reptile species are more sensitive to UVB light, they do need a source of UVB light (and heat). Nocturnal reptile species have a greater efficiency than diurnal reptile species to use UVB for the thermogenesis of vitamin D_3, therefore nocturnal reptile species require lower UVB levels and/or briefer time exposures. The UVB light specifications will affect how long a UVB lamp should be provided (see #3) and the cycle length will vary according to the wild environment in which a species evolved and the appropriate season (e.g., shorter in winter, longer in summer).
6. **Behavioural thermoregulation.** The environment must allow for behavioural thermoregulation meaning the environment should provide a cooler area so the animal can move away from the heat source if the animals body temperature exceeds its comfort zone.
7. **Albino Reptiles.** Do albino reptiles need UVB light? Melanin (pigment) is found in skin and is partially responsible for the colours of most species. Melanin also protects from the harmful effects of UVB light. Albino animals, because they are deficient in melanin, will have a higher sensitivity to UVB. This means they are more likely to have skin damage due to UVB light. However, albino reptiles are dependent on the cutaneous production of vitamin D_3 and this process is both UVB light and heat dependent. Therefore, captive albino reptiles do need a source of UVB light. Albino reptiles may do best when treated as nocturnal reptiles re: UVB exposure. Nocturnal reptiles also are sensitive to UVB exposure and require lower UVB levels and/or briefer time exposures.
8. **Manufacturer instructions:** All UVB lights are not created equal. Therefore, most lights have manufacture-recommended practices such as installation and life-span of the bulb. The UVB lamp should be used in accordance with the manufacturer instructions.
9. **Barriers to UVB.** UVB light does not pass through glass, plastic or mesh.

The Wild Feeding Ecology of Browsing Species

If I had to select one nutritional niche that I most often get consulted on, it is herbivores. In my experience, herbivores in captivity have the highest rate of nutritional pathology than any other nutritional niche. Herbivore species that are also classed as browsers or concentrate selectors (feeders) are especially difficult to feed in captivity to avoid nutritional pathologies.

Why are herbivore species difficult to feed in captivity? There are several reasons, but two main factors are 1) providing the appropriate type and amount of forage to 2) maintain the gut microbial populations. The appropriate type and amount of forage is essential to maintain the gut microbial populations that are necessary for herbivores to use the nutrients provided in the foods they eat. In addition to assisting in digestion, gut microbes produce volatile fatty acids (VFAs), proteins and B vitamins. As much as 70% or more of an herbivores energy needs are met by VFAs.

Within the nutritional niche of herbivore, browsing species are the most likely to have a higher rate of nutritional pathology than other herbivores. What is a browser (concentrate feeder; concentrate selector)? Browsing species, in the wild, eat foods with a higher density of nutrients than species classified as grazers (this explains the "concentrate feeder/selector" name). For example, browsing species typically eat leaves (tree and shrub), forbs (leafy, green plants and their flowers) and aquatic plants. These are foods that have a large amount of cell content (soluble fibres) and they have thinner cell walls (less cellulose and higher lignin levels). The larger plant cell content and thinner cell walls creates the higher density of nutrients.

Browsing species can be non-ruminant (monogastric) animals or ruminant animals. Non-ruminant browsing species include the hippo (pygmy), rhino (black, Indian, Javan and Sumatran) and, tapir. Ruminant browsing species include antelope (e.g., eland, gazelles, gerenuk, kudu, sitatunga, springbok, etc), caribou (reindeer), deer, elk, giraffe, goats (most species including ibex and mountain goats), moose, mountain sheep, musk oxen, and okapi. Some of these species such as deer and musk oxen are also classified as intermediate feeders because they will eat grasses (graze) when grass is available on a seasonal basis. However, in captivity, these species do best when fed as browsers. In general, small herbivore species should be considered browsers because they do not have the large gut capacity for bulky feeds high in cellulose and lower in nutrients.

Species classified as browsing or concentrate feeders have factors common to their physiology and their wild feeding ecology:

1. **Limited digestion of cellulose.** Most wild browsing species do not have cellulase, the enzyme needed to digest cellulose found in grasses and grass hay. Browsers also have faster gut transit times (see #3) that limits their ability to digest cellulose (grass). Therefore, these species can only obtain limited nutrients from plants high in cellulose. A diet high in cellulose, because of a lack of digestibility, can also disrupt the gut microbial population. If captive browsing species are fed hay, they should be fed only alfalfa hay.
2. **Less gut capacity.** Ruminant browsers have a relatively smaller gastrointestinal tract (GIT), especially a smaller stomach for monogastrics and a smaller rumen and omasum for ruminants. The smaller GIT means less gut capacity, therefore their diets must consist of foods with a higher nutrient density and lower fibre foods (e.g., leaves, flowers) when compared to intermediate feeders and grazers. Please note that dietary fibre requirements are lower when ***compared*** to intermediate feeders and grazers. Despite the term "lower fibre", their diets must have very high levels of soluble and insoluble fibre in very specific ratios.
3. **Shorter gut retention time; more hindgut fermentation.** The browser GIT transit time is relatively rapid (including the fermentation rate) because food is not held for very long in the stomach or rumen and most of the plant cellular material continues through the GIT without fermentation. As a result, browsers rely more on hindgut fermentation (cecum and colon) than grazing species. Browsers do have longer colons when compared to grazers. The faster GIT transit time also means browsing species eat less food at a time, but they need to eat more frequently than grazers.
4. **Narrow muzzle.** Browsers have a narrow muzzle or snout that allows for greater manipulation of plant parts and allows selection of specific plant parts by stripping and gnawing.
5. **Long tongues.** Browsing species have relatively long tongues for the selection of specific plant parts.
6. **More mucous glands and large salivary glands.** Browsers have relatively more mucous glands in their lips. Their lips are also relatively thinner and flexible than grazers. Browsers also have the largest salivary glands. These large salivary glands provide more liquid (dilution) to the ingested forage and this facilitates digestion related to the reduced gut retention time (see #3). Salivary gland fluid is essential for maintaining gut pH (especially in the rumen for ruminant species).
7. **Taste buds and food odour.** Browsers have 50% less taste buds on their tongue than grazers. Food odour is more important to these species than it is to browsers.

In captivity, it is essential to formulate diets that respect the gastrointestinal (GIT) function of these species. Essentially, the goal is to feed and support the health of the gut microbial population needed by these species to digest and absorb nutrients from the food they eat.

Diet Considerations: Captive Ruminant Browsers

What factors are important when formulating diets for captive browsers to respect the wild feeding ecology and gastrointestinal (GIT) function of these species? We best understand the important factors for formulating diets by examining those factors that do not feed and support the health of the gut microbial population needed by these species to digest and absorb nutrients from the food they eat.

In this article, you will find information on some diet-related health problems of browsing species and abnormal tooth wear in browsers. As part of that information, there are recommended practices about feeding wood and dead leaves to captive browsers.

Browsers and Diet-related Health Problems (Nutritional Pathology)

In captivity, browsers have shorter lifespans when compared to captive intermediate feeders or captive grazers. This shorter lifespan has been attributed to captive diets high in concentrates and inadequate dietary amounts of forage – a combination that creates acute and chronic acidosis and rumenitis.

Acidosis and Rumenitis. The incidence of acidosis and rumenitis is both as an acute and a chronic condition. These disease processes disrupt the rumen pH and kills gut microflora. The animal loses some ability to digest and absorb nutrients and the result is a loss of nutrients and volatile fatty acids (VFAs) needed for energy and immune function.

The decrease in nutrient absorption is because the change in pH and associated inflammatory processes damages the microvilli lining the rumen. This damage is permanent because scar tissue (dead tissue) develops where healthy, functioning microvilli should be. In addition to a loss of nutrients and decreased immune system functioning, animals will also lose hide and pelt quality.

Rumen acidosis occurs when the rumen pH is below 5.5 (becomes more acidic) for an extended time. This drop in pH changes the product of rumen fermentation from glucose to lactate. The change in pH and the increase in lactate cannot support the normal gut microbial population resulting in an over-growth of some microbes and the death of others. Loss of the appropriate gut microbial population means less volatile fatty acids (VFAs; energy) are produced, fewer nutrients can be digested and absorbed and, the animal will have decreased immune function. In addition, there is a post-acidosis reactive change in the rumen that results in the production of excessive VFAs and this creates further metabolic disturbances.

Rumen acidosis can be acute or subacute (chronic). The cause of acute acidosis is usually ingesting large amounts of grain or other feeds that are high in sugar and starch. Subacute acidosis is usually caused by a daily diet too low in fibre (and types of fibre) and too high in fermentable carbohydrates (sugar and starch).

Symptoms of rumen acidosis include bloat, reduced feed intake, decreased milk production, decreased quality of milk that is produced, diarrhea (foamy feces), laminitis (sole abscesses, etc), liver abscesses, lung hemorrhage, rumenitis and, sudden death syndrome. Secondary symptoms of rumen acidosis such as laminitis, weight loss and poor body condition may not occur until as long as 3 to 6 months after the actual episode of rumen acidosis.

Acidosis and rumenitis also results in loss of calves because females produce less milk and what milk that is produced will be of inferior quality. Calves appear to be nursing, but do not get enough milk and/or enough quality milk and the result is a prolonged starvation state, "failure to thrive" and/or death of the calf.

In general, there is an increase in the incidence of rumen acidosis and rumenitis in any facility holding wild ruminant species. This increase has been attributed to a gradual reliance on complete feeds (e.g., pellets); pelleted feeds high in sugar and starch; a reduction in hays (forage); fruit and vegetables; supplementing with grain and/or sweet feeds; and, sudden increased rations of concentrate feeds pre- or post-calving.

Prevention of rumen acidosis and rumenitis is important to avoid damage to the rumen and avoid the cascade of metabolic disturbances and secondary symptoms. Dietary factors for the prevention of rumen acidosis include:

1. **Fibre amount and type.** Diets must be balanced with the appropriate fibre levels and types of fibre.
2. **Correct ratios of pellets and hay.** Pellets (complete feeds) must be fed with alfalfa hay (forage) at an appropriate ratio of hay to pellets. The appropriate ratio of hay to pellets depends on life-stage and reproductive stage. In general, pellets should be fed at 30% to 40% of the diet and alfalfa hay at 60% to 70% of the diet. Percentages will also vary depending on the size of the animal. Smaller species should receive a 50% pellet to hay ratio because they have limited gut fill.

. . . . . . ***Continued Page 10***

3. **Do not overfeed.** Avoid overfeeding at any one feeding and/or in all feedings. The daily feed ration should be based on the metabolic, life-stage and seasonal energy needs of an animal then divided equally into – at least - twice daily feedings.
4. **Hay then concentrates.** Feed hay before concentrates.
5. **Low-sugar, low-starch.** Use low-sugar (< 5%), low-starch (< 5%) formulated feeds. Ask your feed provider for the sugar and starch percentages of your feed.
6. **Remove fruit and vegetables.** Domesticated fruits and vegetables are too high in sugars and starch and too low in fibres to be appropriate feeds for herbivores and especially for browsing species.
7. **Avoid abrupt dietary fibre changes.** Avoid abrupt switches from a high fibre diet to a diet lower in fibre (or vice versa). For example, an abrupt dietary change from a higher fibre diet to a lower fibre diet is usually experienced by pregnant females pre- or post-calving because dietary concentrates (pellets) are usually increased in a misguided effort to provide energy for lactation. Pregnant females pre-and post-calving should gradually be put on a 50% pellet to hay ratio and their rations should be gradually increased to ad lib feeding post-calving. When the calf is weaned, the female should be gradually re-introduced to the normal diet ratio of pellet to hay.

Tooth Wear in Captive Browser. Captive browsers are prone to excessive tooth wear due to inappropriate feed. Browsing and grazing species have evolved differences in dentition based on diet. Grazing species, for example, have evolved dentition with high teeth crowns and adaptations for teeth shear needed to chew grasses and limit the abrasion caused by silica (crystals) in grasses. Browsers do not have these adaptations and will develop excessive dental erosion when fed grass diets. In captivity, grazers ***and*** browsers are most often fed grass hays (or diets high in grass hay), and this means captive browsers develop considerable tooth wear. In general, browsers should be fed diets low in silica by feeding legumes like alfalfa hay or natural browse.

Wood and browsing species. A common misconception about the wild feeding ecology of browsing species is the ingestion of wood. In general, browsing species use their long tongues and large mouths to strip foliage from branches. While this may result in eating the tips of some small branches, the woody material intake is minimal. Some browsing species (e.g., moose) have been reported eating bark from trees. However, these reports are usually in winter when food is scarce: in other words, the bark is a starvation or survival food. To illustrate how wood is only a survival food, the digestibility of tree wood in adult moose is only 29.3% for willow, 27.7% for ash and 8.8% for birch (Schwartz et al, 1988). The digestibility of bark averages at only 18.3%. These low percentages of digestibility mean that the animals extract minimal nutrition from the wood or bark because most of the ingested wood or bark is excreted as waste. Young animals with immature GITs and gut microbial populations will have even lower percentages of digestibility. A similar dietary choice is lichen. Lichens are another starvation (survival) food – eaten when food is scarce - because it provides minimal nutrients, yet is available when other food resources are limited.

Fallen leaves and browsing species. Another common misconception about the wild feeding ecology of browsing species is the belief that fallen leaves are a good food source. Fallen leaves are used as survival foods for many North American browsing species in the winter. However, the key word – again - is "survival" meaning fallen leaves provide an extremely low density of nutrients during seasons when foods are scarce. For example, the digestibility of fallen leaves in caribou and moose is only 21% for birch (*Betula sp*) and 33% for willow (*Salix sp*) (Klein, 1990). Protein (nitrogen) **loss** in fallen leaves averages at 64.3% in willow and 74.7% in birch (Scotter, 1972).

Introducing: CAZA Wildlife Nutrition

After nearly two years of planning, we are pleased to announce CAZA Wildlife Nutrition, a completely new line of specially formulated nutritional products designed for the needs of captive wildlife.

CAZA Wildlife Nutrition is the first and only feed manufacturer in Canada to focus specifically on captive wildlife nutrition. All our products are formulated based on the wild feeding ecology of captive wildlife. Our products are made only with ingredients that provide the same, or similar, nutrients in function and form as wild feeding ecology.

CAZA AZAC

Wildlife Nutrition
Aliments pour faune sauvage

In addition to providing captive wildlife feeds based on wild feeding ecology, CAZA Wildlife Nutrition also offers the services of a highly qualified wildlife nutritionist to assist you in selecting the best possible feed for your captive wildlife. The services of the wildlife nutritionist are also available to clients for advice during the transition period to a CAZA Wildlife Nutrition product.

CAZA Wildlife Nutrition offers benefits beyond appropriate nutrition for captive wildlife and the services of a wildlife nutritionist. Our prices are lower than imported products because CAZA Wildlife Nutrition products are manufactured in Canada. Your feed will be made fresh at the time of your order preventing problems that may occur from long-term storage. We also offer delivery quotes for your order with the lowest prices in the feed transport industry.

We are beginning this new enterprise with the introduction of our CAZA Wildlife Nutrition Browser pellet. Our browser pellet has been formulated based on the wild feeding ecology of browsing ruminant species. It is a low-sugar, low-starch pellet that offers the appropriate types and ratios of fibre recommended for browsing ruminant species.

We also offer custom feed formulation services to our clients. This service will meet the needs of clients who have tried to obtain a product for some of their animals, but that product is not available or is not affordable.

Please contact our wildlife nutritionist for further information:

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Deborah McWilliams is a wildlife nutritionist and founder of the Canadian Association of Zoos and Aquariums Nutrition Advisory and Research Group (CAZA-NARG). She has 15 years of experience in wildlife nutrition and has worked with zoological institutions and wildlife parks and preserves internationally as a consultant, workshop presenter and educator in wildlife nutrition. In addition, Deborah is a nutrition advisor for the CAZA Herpetology Taxon Advisory Group (TAG) and for the American Association of Zoos and Aquariums Rodent, Insectivore and Lagomorph TAG (AZA RIL-TAG). Deborah published the first edition of “Applied Zoo Animal Nutrition” in 2010 and this book is used by zoological institutions in eight countries.

Factors Impeding the Improvement of Captive Wildlife Diets Using Wild Feeding Ecology

For the past 15 years working with wildlife institutions and organizations, I have had the pleasure of working with a wide variety of committed professionals dedicated to the welfare of the animals in their care. However, there are factors that impede the provision of appropriate nutrition to captive wildlife and these factors first need to be recognized and examined before they can be successfully eradicated.

Factors limiting the improvement of diets for captive wildlife are most often related to a lack of foods, commercial feeds, geographic location (Canada) and available time and skills. In general, these factors can be consolidated into two major challenges for Canadian wildlife institutions and organizations: I) Lack of Affordable and Appropriate Feeds for Captive Wildlife and II) An Insufficiency of Skills and Time in a Typical Zoological Institution.

I. Lack of Affordable and Appropriate Feeds for Captive Wildlife

Food appropriate for captive wildlife can be a challenge. Institutions and organizations here in North America often do not have access to foods eaten by species on other continents. In many ways, this can be the least challenging factor because we can often substitute with foods available locally if we 1) know the composition of the wild diet 2) know the nutrient content of those foods in the wild diet and, 3) use foods common in North America that compares favourably to the nutrient composition of foods in the wild diet.

The most challenging factors, however, in the development of nutritional pathology in captive wildlife includes the use of feeds formulated for food and pet animals; a lack of appropriate formulated feeds; and, a lack of affordable feeds.

Feeds for Food Animals. Most feeds being used in zoological institutions are based on standards for food animals and pet animals. These standards are developed and recognized by various organizations including the government (federal and provincial), the National Research Council (NRC) and, manufacturing organizations. For example, if a zoo animal is classed as a large ruminant, the zoo is usually sold a feed developed for dairy cows and/or beef cattle.

Research indicates that captive wildlife develops myriad pathologies directly or indirectly related to their diet when fed by standards developed for food animals. This is understandable given the difference in physiologies of food animals and captive wildlife. For example, food animals have extremely short lifetimes in which they must increase body mass and/or produce large amounts of milk or eggs. When feeds formulated to support fast gain and massive production are fed to captive wildlife with nonproduction physiologies – animals that should have slower growth curves and longer life spans - the results are shortened lives and reduced welfare based on nutritional pathologies.

To understand fully the above principle, we should compare the life span of food animals to what should be the life span of captive wildlife. Table 1 (page 13) compares the average life span of typical food animals to what should be the average life span of analogous captive wildlife. It is apparent, based on expected life years, that there should be a huge difference in nutrient requirements for animals raised for food (eggs, meat, milk) compared to those of captive wildlife. The density of nutrients and energy (calories) producing gain in an animal in a few months and/or to produce massive amounts of milk or eggs is not appropriate for an animal that should have a gradual growth curve and/or who produces eggs and milk only during reproductive seasons.

I will also illustrate using production indices for commercial egg-layers. Table 2 (page 13) compares the average egg production in food avian species compared to analogous captive wildlife species. Again, the density of nutrients and energy (calories) required to support the production of a commercial egg layer is inappropriate for the seasonal egg-laying of captive wildlife.

The same principles apply to many feeds labelled for animals such as ratites or deer. These feeds are designed to be fed to ratites or deer, often called "exotic animals" or "wild animals", but these are animals raised as alternative livestock. As alternative livestock, these animals have short life spans and are produced for rapid growth and massive gain. This means that a feed designed for an ostrich destined to enter the meat industry is not the appropriate feed for an ostrich held in a zoological institution.

Table 1. A comparison of the average life span of food animals to analogous wildlife.

Species of Food Animal	Food Animal	Wildlife Life span
Bison	18 - 3- months	25 years
Chicken, layer	12-18 months	6-9 years depending on breed
Chicken, broiler	3 to 4 months	
Cow, dairy	3 years	25-30 years
Cow, dairy breeder	5 - 7 years	
Cow, beef Steer and heifer	15-20 months	20-25 years
Elk	< 3 years	13-18 years
Emu, meat	12 - 18 months	15- 20 years
Emu, breeder	6 years	
Ostrich, meat	12 months	20 - 30 years
Ostrich, breeder	6 years	
Pig, meat	4 - 5 months	15 years
Pig, breeder	3 - 5 years	
Sheep, meat	6 months	15 years
Sheep, breeder	5 - 7 years	
Turkey, meat	16 weeks	12 years
Turkey, breeder	2 - 6 years	

Table 2. Comparison of the average egg production of commercial avian species to analogous wild species.

Bird Species	Commercial Layer Eggs per Year	Wild Species Eggs per Year
Chicken	300+	10 - 15
Duck	125 - 225	7 - 10
Emu	30 - 50	8 - 12
Ostrich	40 - 100	11 - 19
Turkey	100 - 110	10 - 12

. . . . . Continued on page 14

Feeds for Pet Animals. Foods designed for domestic pets are also used inappropriately for captive wildlife. The most common pet foods used for some captive wildlife species are canine and feline pet foods.

The feeds for domesticated canines, for example, are designed for animals that have been purpose-bred over thousands of years to survive on an omnivore diet as they co-exist with humans. The result is that our domesticated canines are omnivores. However, wild canids such as coyotes, fox and wolves are obligate carnivores and have not evolved to be omnivores. When wild canine species held at most zoological institutions are fed as omnivores, they develop nutritional pathologies.

It is a similar situation for the use of feline pet foods with captive, wild feline species. The domesticated cat has also been purpose-bred to survive on a diet higher in carbohydrates than the diet of wild felids.

Appropriate Formulated Feeds. Commercial feeds for wildlife are available. These are "complete feeds" meaning they provide a wide spectrum of nutrients intended to meet the dietary needs of the species. If a commercial feed does not provide optimum nutrition, it is because of the goals used when formulating the feed (see "Feeds for Food Animals" and "Feeds for Pet Animals" above). For an example, most commercial feeds for browsing hoof stock such as moose are based on domestic livestock. As a result, these feeds contain over 50 % to 100% the amount of sugars as recommended by zoo and wildlife nutritionists for captive browsing species.

In addition, some commercial feeds contain ingredients meant to increase fibre levels but the ingredients are inappropriate in form and function. For example, browser feeds often contain wood products (e.g., wood shavings, sawdust). These wood products often are by-products of the lumber industry and possibly may be contaminated with petroleum products and heavy metals. An indication that the level of contamination may be considerable is that such wood by-products are certified as unfit for use as mulch for crops in the human food industry. Wood products (e.g., wood shavings, sawdust) cannot be used as mulch for food crops because of the leaching of contaminants from the wood into the soil. The leached contaminants are then assimilated into the plant. While these feeds with wood products may have improved the life span of some captive browsers (for example, an increase from 3-4 years to 6-8 years for moose), moose should live 15 to 25 years.

Affordable Feeds. Most specialty feeds available for captive wildlife are not produced in Canada. Manufacture of these feeds in other countries require importation into Canada. The importation of feed adds cost to the feed (e.g., import duty, broker fees, etc). In addition, importation from other countries greatly increases transportation costs. The result is that these feeds must be sold at a premium meaning zoological institutions may use minimal amounts; use the feed inappropriately; and/or cannot afford to purchase premium feeds.

When specialty feeds are not affordable, an institution or organization may only have the availability of feeds produced by local a feed manufacturer. Local feed manufacturers are, with very few exceptions, trained in farm animal and pet animal nutrition and their products are most suited to the food and pet animal industries - not to sustain captive wildlife.

II. An Insufficiency of Skills and Time.

A co-factor in the development of nutritional pathologies in captive wildlife is the lack of appropriate professional skills and sufficient time:

Skills. The responsibility for formulating diets in many zoological institutions are most often in the care of someone without training in animal nutrition. In general, the recommended education and skills for a wildlife nutritionist is a minimum of a Master's degree in animal nutrition with 5 to 10 years dietary experience with wildlife (wild or captive).

Time. Not only do most of the individuals responsible for diets in many zoological institutions lack training in animal nutrition, they often have several job responsibilities other than responsibility for animal diets. For example, often a veterinarian, curator or keeper has the responsibility of animal diets added to their job description. These multiple responsibilities usually determine that the formulation and review of diets is often neglected or afforded cursory attention. In addition, individuals with multiple job responsibilities most often do not have the time to keep current with research on wild feeding ecology or on captive wildlife. This means they will lack the information necessary to improve the diets of the animals in their care and to negotiate with feed manufacturers for appropriate feeds for their animals.

This Issue: Picture and Comments

Considering that page 11 of this newsletter introduces "CAZA Wildlife Nutrition", you might tend to see the information provided in this last article as incentive to purchase CAZA Wildlife Nutrition products. It is not, yet it is.

It is not an incentive to purchase CAZA Wildlife Nutrition products because the problems presented in "Factors Impeding the Improvement of Captive Wildlife Diets. . . " **are very real problems for wildlife professionals that need to be closely examined and discussed openly among us.** ***The preceding article examines and discusses those problems. As a result, it should serve to also be an important educational tool to understand the limits of available feeds and the health problems that may result from their use.***

It is an incentive to purchase CAZA Wildlife Nutrition products because the problems presented in this article are the reasons why CAZA Wildlife Nutrition exists today. We believe it is possible to produce affordable products of quality for captive wildlife, in Canada, if we respect the wild feeding ecology and physiology of a species.

During the course of my career, I have contacted Canadian feed manufacturers to invest in the production of feeds appropriate for captive wildlife. In general, Canadian feed manufacturers have responded that wildlife nutrition is not a large enough market to devote development and manufacture resources. In addition, they believe existing products are sufficient for captive wildlife.

Therefore, CAZA and CAZA-NARG have worked for nearly two years to create a solution that provides wildlife professionals with affordable feeds that support the health of the captive wildlife in their care. The result is "CAZA Wildlife Nutrition".

We look forward to serving you.

Deb McWilliams

Deb McWilliams, Yukon Wildlife Preserve (Whitehorse, Yukon), 2011