AN OVERVIEW OF THE NUTRITION OF ZOO ANIMALS IN THE MIDDLE EAST

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Nutrient requirements of zoo animals are best described as the types, amounts, ratios and presentations of nutrients to support a near equivalent of natural life, reproduction and well-being of the captive animal. The variety of wildlife species kept in captivity in the Middle East is large and as a result so is the variability in nutritional ecology, digestive physiology and nutrient utilization (Van Soest, 1982; Hofmann, 1989). Consequently the feeding requirements vary considerably between different species (Ulrey, 1996). For example, browsers such as giraffe (*Giraffa camelopardalis*) are thought to require browse to stimulate gut function and behavioural health and tend to select feeds relatively high in protein (Hofmann, 2000; Claus et al, 2003). Conversely, grazers such as Arabian oryx (*Oryx leucoryx*) can be kept successfully on grass hay with small daily amounts of a low protein supplement.

Nutrient utilization can vary due to anti-nutritive factors and nutrient ratios (Robbins, 2001). For example, the availability of phosphorus (P), calcium (Ca), magnesium (Mg) and zinc (Zn) naturally bound with phytic acid in plants is limited for many monogastric animals (e.g. birds, primates), this is of no concern for ruminating animals because the phytate is destroyed by foregut microbial digestion. However, does phytate limit the availability of these minerals in hindgut fermenters such as horses or elephants? There is no clear evidence (NRC, 2006) that phytate limits phosphorous uptake in the domestic horse (*Equus caballus*). Phytates are prevalent in some foods such as seeds (grains) and brans (Maynard, 1984), and accounting for P, Ca, Mg and Zn supply in these foods in species that are considered to be unable to break down phytate requires caution. Additional nutrient balancing (e.g. with manufactured phytase) might be required and is widely practiced in commercial poultry and swine feeds (NRC, 1988; NRC, 1994). However, the levels of grains and grain products should be limited in the diets of phytate sensitive species.

For several species there is considerable variation in nutrient requirements if one allows for seasonality and changes in the physiological state (e.g. growing or lactating) of the animals (Lechner–Doll, 2000). Variation in body condition is part of many nutritional ecologies. Varying the types of feeds and feeding levels can help to mimic seasonality in captivity which, it is argued, helps maintain a healthy animal with a natural body condition (Lechner-Doll 2000).

Gerenuk feeding on browse trees at Wadi al Safa Wildlife Centre, Dubai (©Declan O'Donovan).

Boredom and obesity are major problems in zoo animals in general and feed-related stereotypic behaviours, due to limitations of natural stimulants, are common (Ulrey, 1996). Good nutritional management includes not only meeting the animal's differing physiological requirements, but also consideration for its psychological well-being. Unfortunately, many keepers tend to offer their animals very digestible, processed and often nutritionally unbalanced feeds (e.g. high energy pellets, young grass, boneless meat etc.) and make these available ad-lib, which leads to over consumption and disease. For example; feeding too much energy (mostly from sugars, starches and fructans) through either pellets, grain or grass can cause metabolic bone disease (mbd) in ratites (Bennet et al, 1991) and rumen acidosis in zoo ungulates (Van Soest, 1996); feeding de-boned meat (often done for reasons of tidiness) to captive carnivores and raptors is sadly a common practice and leads to mbd, suffering and death. Internal skeletons of prey animals are a major source of minerals for predators (Robbins, 2001) therefore, their captive diets should consist of (parts of) whole carcasses.

Ad-lib feeding of processed and unbalanced feeds may satisfy the animal in the short term, but eliminates the need for natural foraging and feeding behaviour and may even induce stereotypic behaviours. Food should be provided in a habitat in which the animals can feed as naturally as possible and consume the correct amount (by avoiding oversupplying and bullying). Animals should be fed according to their body condition and feeding enrichment techniques with feeding behavioural aids can be used to increase the animal's natural behaviours. Examples include:

- provide treats to carnivores inside a box, feed tube or ball with a small hole, forcing them to turn it around in an effort to obtain feed.
- vary a fox diet with farmed prey animals like rodents, birds and insects.
- feed live insects hidden under leaves to insectivores.
- feed fruits or fruit juice embedded in ice for primates; use timed automatic feeders.
- feed browse in as natural a way as possible
- alternate the provision of killed or live prey to carnivores.

Captive conditions may require that additional nutrients are added to the diet. For example; vitamin C in feed is essential (Robbins, 2001) for bats (*Chiroptera*), guinea pigs (*Cavia porcellus*), primates (*Anthropoidea*) and approximately one half of all perching birds

(*Passeriformes*); the amount of light and wavelength are essential for vitamin D production in reptiles kept indoors (Lloyd, 2006); In contrast, browsers like gerenuk (*Litocranius walleri*), kept at low stocking densities in some parks normally often do well without any additional feeding, provided they have sufficient browse available.

Cheetah cub with bilateral hip abnormality showing poor stance caused by poor nutrition (©Florine de Haas van Dorsser).

In addition one needs to know the nutrients being fed, then balance and feed effectively. For example; Rhodes hay, common in the Middle East, is generally high in salts, low to deficient in selenium (Se) and its copper (Cu) availability (as opposed to content) is likely to be low. Therefore supplying additional trace mineral (Se and Cu) in a salt lick to avoid trace mineral deficiency is not necessarily sufficient. Due to the consumption of the (salty) hay, the urge to consume the lick block will diminish or disappear.

Industrial domestic animal feeds are generally made to stimulate animal growth or production performance in the short term and are usually fortified to "specific species performance requirement". For example; the recommendation for Vit D_3 in broiler diets is below the requirement (NRC, 1994) to make strong and long lasting bones, because it is not desired. Therefore houbara bustard (*Chlamydotis undulata*) or stone curlew (*Burhinus oedicnemus*) chicks cannot be fed successfully on broiler feeds. However, knowledge from domestic animal nutrition research can also be extrapolated to zoo animal diets. For example; the efficiency of absorption of a nutrient like Ca from a feed like alfalfa is approximately 3x times higher in domestic horses than in domestic cattle (*Bos taurus*), which is probably due to differences in their digestive physiology (NRC, 2001 and NRC 2006). Diet formulation for wild *Equidae* and *Rhinocerídae* are supported by this nutrition research.

The hot climate of the Middle East region requires that extra electrolytes (mainly Na, K, and Cl) are offered to compensate for losses through sweating and increased kidney excretion, due to panting and evaporation induced alkalosis (Schmidt-Nielsen, 1990, Borges et al, 2007). Water is most important in a hot, dry climate and water quality is an important factor to consider when formulating diets. For example; water from wells in the region is often quite salty. Thus feeds commonly fortified with salt could cause the diet to become too alkaline (i.e. high in Na, K and Mg). In alkaline conditions a good feed to use additionally could be wheat bran which has low Na and K.

Animal managers should consider using new knowledge from nutrition science. For example; prebiotics like fructo-oligosacharides (Vancaeneghem et al, 2002), mannan-oligosaccharides (Cotter et al, 2002) are replacing feed antibiotics and are considered immune stimulants. Plant secondary metabolites (PSM's) like condensed tannins derived from trees, shrubs and forages like aspen (*Populus tremula*), sulla (*Hedysarum coronarium*) and sainfoin (*Onobrychis viceafolia*), act as natural de-wormers (Mefod'ev,1996, Niezen et al, 1998, Molan et al, 2002, Hoste et al, 2005,); tannins are effective against bacteria, fungi and viruses (Claus, 2003); certain barks from willows (*Salix* sp.) and aspen (*Populus trimula*) are known to provide natural anti-inflammatory properties (Von Kreudener et al 1996). Caution is required however, as most PSM's also have anti-nutritional effects (Athanasiadou, 2004). Naturally bound Se (i.e. Se similar to levels found naturally in seeds) has a major positive impact on productive animal's health (Lyons, 2002) and common levels of nutrients (iron and vitamin A) in industrial domestic animal feeds are implicated in iron storage disease in frugivorous and omnivorous animals (Claus, 2006, Huisman, 2006, McDonald, 2006). Finally the use of gluten free feeds for gluten intolerant species, such as red-bellied tamarins (*Saguinus labiatus*) seems to work. (Berndt et al, 2006).

Radiograph of a Bonelli's eagle chick with metabolic bone disease (©Tom Bailey).

Generally a zoo animal display is the outcome of a compromise between the needs of the captive animal and the requirements and available resources of the zoological collection. Traditionally zoo animal keepers have studied and developed diets for zoo animals. Most zoo animals are nutritionally and behaviourally adaptive, allowing people to keep them in captivity with variable degrees of success. It is advisable to feed captive wild animals as naturally as possible, i.e. feed what the species would eat while in its original habitat, and to use knowledge of nutrition from wild and domestic species as a guide. Zoo animal nutrition is an important and complex subject and the advice of a zoo animal nutritionist can have far reaching benefits for a captive wild animal collection.

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