

CHEETAH NUTRITION: RECENT ADVANCES AND REVISED SSP RECOMMENDATIONS

Ellen Dierenfeld^{1}, Katherine Kerr^{2,3}, Katherine Whitehouse-Tedd⁴*

¹ *Ellen S. Dierenfeld Nutrition Consulting, LLC, St. Louis, Missouri, USA*

² *University of Florida, Gainesville, Florida, USA*

³ *Disney's Animal Kingdom, Lake Buena Vista, Florida, USA*

⁴ *Cheetah Outreach, Somerset West, South Africa*

Abstract

The SSP Cheetah Animal Care Manual was recently revised and updated, and is due for release by the end of 2015. As part of this process the Nutrition chapter was re-written in order to incorporate recent research findings and provide a more comprehensive overview of our current understanding. A review of the *in situ* diet of the free-ranging cheetahs demonstrated a preference for medium-sized ungulate prey, although smaller prey such as hares and large prey including kudu were also important dietary components according to various studies (Marker et al., 2003; Hayward et al., 2006). The prey preference of the wild cheetah is thought to reflect morphological adaptations, prey availability within cheetah range, as well as behavioral considerations for a species which is typically unsuccessful in defending prey against kleptoparasites. In order to best utilize findings from wild cheetah diets when evaluating or formulating diets for captive animals we compiled a table comparing the nutrient composition of the various natural prey species. A significant gap in the literature was subsequently identified whereby nutritional composition data was typically missing or only partially available (e.g. excluding micronutrients such as essential vitamins and minerals) for the majority of wild prey and even their domestic counterparts. For example, few data exist on the nutrient composition of whole ungulate carcasses; extrapolation of mineral data from Holstein calves suggested that trace minerals may be quite variable in particular, and the contribution of bone or non-meat carcass elements to nutrient profiles was unknown.

In terms of recent advances in our understanding of cheetah digestive function, the role of the gastrointestinal microbiota was highlighted. Researchers in cheetah (and other carnivore species) nutrition are increasingly including changes in the microbial community of the hindgut as a key parameter by which to assess dietary influence on animal health (Depauw et al., 2011, 2014b; Becker et al., 2014). Perturbations of the gut microbial populations and resultant fermentation activities can have important consequences for the overall health of the cheetah. Hind gut fermentation is highly influenced by diet, and in particular the fibrous (indigestible) component is considered important in this respect. Evidence for the beneficial effect of both plant and animal fibers in the fermentation patterns of captive cheetahs indicates that whole prey diets, or meat-diets supplemented with an appropriate plant fiber source, are necessary to promote gut health (Vester et al., 2008; Depauw et al., 2011; 2014; Kerr et al., 2013a). To this end, the use of pre- and probiotics was evaluated, and the potential pre-biotic activity of animal or plant fiber sources was considered worthy of further investigation (Koeppel et al., 2006. Vester et al., 2010; Depauw et al., 2011; 2012; de Godoy et al., 2013; Kerr et al., 2013a; 2013b). Whilst species-specific nutrient requirements are still unknown for the cheetah, known requirements for the domestic cat, as a model for the cheetah, were included for various life stages (weaning,

maintenance and reproduction; NRC, 2006). These values, alongside values reported for wild-type prey, provide an important benchmark against which to evaluate captive diets. Recent epidemiological evidence has revealed a geographical bias towards the use of commercially prepared diets in North America, compared to supplemented muscle meat and carcass provision outside of this continent (Whitehouse-Tedd et al., 2015). The majority of commercially prepared diets comprised ground horse or beef meat and the relative lack of fiber in these diets warrants a cautionary approach to their use as the sole source of nutrition for captive cheetahs. Furthermore, an epidemiological association was demonstrated between the feeding of horse meat on a regular basis (once a week or more) and an increased risk of gastritis (Whitehouse-Tedd et al., 2015).

A recommendation was made towards the inclusion of size-appropriate bones to improve dental health, encourage natural feeding behaviors, and provide supplementary animal fiber. However, the practice of providing animals with gnawing bones in the absence of a meal, i.e. on fasting days was discouraged. Moreover, the use of fasting days is no longer advised for cheetahs due to preliminary research indicating potentially negative consequences of fasting on animal behavior and fecal consistency. Instead, feeding enrichment, including randomized feeding schedules, should be prioritized over set fasting days (Quirke and O’Riordon, 2011).

Nutritional disorders are unfortunately still relatively frequently reported in captive cheetahs. Whilst the requirement for a balanced Ca:P ratio has been known for many decades, incidents of MBD have been reported as recently as 2011 (Bell et al., 2011). Additionally, copper deficiency and hypervitaminosis A were among a number of nutritional disorders still requiring particular attention in this species. Typically inappropriate supplement regimes were etiological in the nutritional disorders reported, including insufficient copper supplementation of poultry-based diets (Kaiser et al., 2014), or excessive provision of vitamin A (or liver).

Diet suitability and monitoring of nutritional status were highlighted as key elements to any nutrition program. Databases such as Zootrition® or Fauna® enable the chemical composition of most diets to be evaluated without the need for laboratory analyses, whilst standardized fecal consistency and body condition scoring systems are also available for this species (Dierenfeld et al., 2007; Whitehouse-Tedd et al., 2015). The signs of nutrient deficiencies or toxicities are well reported in the scientific literature and via the NAG and therefore widely available to zoological facilities. Combined, these monitoring tools provide ample opportunity for the monitoring of cheetah nutritional health to be incorporated into regular and routine veterinary examinations as well as daily keeper assessments. Likewise, protocols for the conduct of digestibility and feed intake can be found online, whilst the monitoring of serum biochemistry (Dierenfeld, 1993; Bechert et al., 2002; Depauw et al., 2012; Kaiser et al., 2014), as well as certain biomarkers of inflammation (Depauw et al., 2014a; 2014b) are available for those facilities interested in pursuing more comprehensive evaluations. However, it is imperative that the review of dietary suitability should include the services of a qualified animal nutritionist in order to ensure correct data interpretation.

Combining global research and feeding practices, including information from range habitats and integrated scientific disciplines, for any of our managed species provides a more comprehensive understanding and rapid advances towards optimized diets and nutritional management.

Literature Cited

- Bechert, U., Mortenson, J., Dierenfeld, E.S., Cheeke, P., Keller, M., Holick, M., Chen, T.C., and Rogers, Q. (2002) Diet composition and blood values of captive cheetahs (*Acinonyx jubatus*) fed either supplemented meat or commercial food preparations. *J Zoo Wild Med* 33(1): 16-28.
- Becker, A.A.M.J., Hesta, M., Hollants, J., Janssens, G.P.J., & Huys, G. (2014) Phylogenetic analysis of faecal microbiota from captive cheetahs reveals underrepresentation of *Bacteroidetes* and *Bifidobacteriaceae*. *BMC Microbiology* 14:43.
- Bell, K.M., van Zyl, M., Ugarte, C.E., Hartman, A. (2011) Bilateral carpal valgus deformity in hand-reared cheetah cubs (*Acinonyx jubatus*). *Zoo Biol* 30(2): 199 – 204.
- de Godoy, M.R.C., Kerr, K.R., & Fahey Jr., G.C. (2013) Alternative dietary fiber sources in companion animal nutrition. *Nutrients* 5: 3099-3117.
- Depauw, S., Hesta, M., Whitehouse-Tedd, K., Vanhaecke, L., Verbrugghe, A. & Janssens, G.P.J. (2011) Animal fibre: the forgotten nutrient in strict carnivores? First insights in the cheetah. *J Anim Physiol Anim Nutr* 97: 146–157.
- Depauw, S., Bosch, G., Hesta, M., Whitehouse-Tedd, K., Hendriks, W., Kaandorp, J., & Janssens, G.P.J. (2012) Fermentation of animal components in strict carnivores: a comparative study with cheetah fecal inoculum. *J Anim Sci* 90: 2540–2548.
- Depauw, S., Delanghe, J., Whitehouse-Tedd, K., Kjelgaard-Hanse, M., Christensen, M., Tugirimana, P., Vercammen, P., Hesta, M., & Janssens, G.P.J. (2014a) Serum protein capillary electrophoresis and measurement of acute phase proteins in a captive cheetah population. *J Zoo Wild Med* 45(3): 497-506.
- Depauw, S., Heilmann, R.M, Whitehouse-Tedd, K., Hesta, M., Steiner, J.M., Suchodolski, J.S. & Janssens, G.P.J. (2014b) Effect of diet type on serum and faecal concentration of S100/calgranulins in the captive cheetah. *J Zoo Aquarium Res* 2: 33-38.
- Dierenfeld, E.S. (1993) Nutrition of captive cheetahs: food composition and blood parameters. *Zoo Biol* 12: 143-150.
- Dierenfeld, E.S., Fuller, L. & Meeks, K. (2007). Development of a standardized body condition score for cheetahs (*Acinonyx jubatus*). *Proc. 7th AZA Nutrition Advisory Group Conference*, Knoxville.
- Hayward, M.W., Hofmeyr, M., O'Brien, J., & Kerley, G.I.H. (2006) Prey preferences of the cheetah (*Acinonyx jubatus*) (Felidae: Carnivora): morphological limitations or the need to capture rapidly consumable prey before kleptoparasites arrive? *J Zool* 270: 615-627.

- Kaiser, C., Wenery, U., Kinne, J., Marker, L., & Liesegang, A. (2014) The role of copper and vitamin A deficiencies leading to neurological signs in captive cheetahs (*Acinonyx jubatus*) and lions (*Panthera leo*) in the United Arab Emirates. *Food Nutr Sci* 5: 1978-1990.
- Kerr, K.R., Morris, C.L, Burke, S.L., & Swanson, K.S. (2013a) Influence of dietary fiber type and amount on nutrient digestibility, fecal characteristics, and fecal fermentative end-product concentrations for captive exotic felids fed a raw beef-based diet. *J Anim Sci* 91: 2199-2210.
- Kerr, K.R., Beloshapka, A.N., Morris, C.L., Parsons, C.M., Burke, S.L., Utterback, P.L., & Swanson, K.S. (2013b) Evaluation of four raw meat diets using domestic cats, captive exotic felids, and cecetomized roosters. *J Anim Sci* 91: 225-237.
- Koepfel, K.N., Bertschjinger, H., van Vuuren, M., Picard, J., Steiner, J., Williams, D., & Cardwell, J. (2006) The use of a probiotic in captive cheetahs (*Acinonyx jubatus*). *Journal of the South African Veterinary Association* 77: 127-130.
- Marker, L.L., Muntifering, J.R., Dickman, A.J. Mills, M.G.L, Macdonald, D.W. 2003. Quantifying prey preferences of free-ranging Namibian cheetahs. *S Africa J Wild Res* 33: 43-53.
- [NRC] National Research Council. (2006) *Nutrient Requirements of Dogs and Cats*. Washington DC: National Academy of Sciences. 424 pp.
- Quirke, T., & O’Riordan, R.M. (2011) The effect of a randomised enrichment schedule on the behaviour of cheetah (*Acinonyx jubatus*). *Appl Anim Behav Sci* 135: 103-109.
- Vester, B.M, Burke, S.L, Dikeman, C.L., Simmons, L.G. & Swanson, K.S. (2008) Nutrient digestibility and fecal characteristics are different among captive exotic felids fed a beef-based raw diet. *Zoo Biol* 27: 126-136.
- Vester, B.M, Beloshpka, A.N, Middelbos, I.S., Burke, S.L., Dikeman, C.L., Simmons, L.G., & Swanson, K.S. (2010) Evaluation of nutrient digestibility and fecal characteristics of exotic felids fed horse- or beef-based diets: use of the domestic cat as a model for exotic felids. *Zoo Biol* 29: 432-448.
- Whitehouse-Tedd, K.M., Lefebvre, S.L., & Janssens, G.P.J. (2015) Dietary factors associated with faecal consistency and other indicators of gastrointestinal health in the captive cheetah (*Acinonyx jubatus*). *PLoS ONE* 10(4): e0120903. doi:10.1371/journal.pone.0120903