IDEAL PROTEIN AND ZOO CARNIVORES: FURTHER CONSIDERATIONS FOR OPTIMIZING DIETS

Ellen S. Dierenfeld, PhD, Karen J. Wedekind, PhD, Ingomar Middelbos, PhD*

Novus International, Inc., St. Charles, MO 63304 USA

ABSTRACT

Carnivorous zoo species are often fed “natural product” diets, i.e. raw meat-based meals for large felids, whole vertebrate prey, entire fish for aquatic or otherwise piscivorous species, and/or a variety of invertebrates consumed by insectivores. In general, these types of diets contain relative excess protein compared to nutritional requirements established for domestic cats and dogs, (NRC, 2006) or production species such as mink, (Sandbol et al., 2004) with little emphasis on specific amino acid balance. Nonetheless, balanced amino acids and proper protein:energy ratios are essential to optimal health and nutrition (Wedekind, 2011).

Ideal protein ratios, generally established relative to lysine as the first limiting amino acid, (Baker and Czarnecki-Maulden, 1991) vary across species (Baker and Czarnecki-Maulden, 1991; Kaushik, 1998; Sandbol et al., 2004) even within largely carnivorous species. (Table 1)

Review of compositional data from common raw meats suggests possible differences in amino acid (AA) profiles between domestically-reared livestock species and equivalent “wild” meat species (Tables 2 and 3). (USDA, ARS) Nonetheless, all meats examined, regardless of source, appear to be limiting in arginine (Arg), leucine (Leu), sulfur AA (SAA) methionine plus cysteine (Met + Cys), and phenylalanine plus tyrosine (Phe + Tyr), compared to requirements established for obligate carnivores.

Amino acid composition data on whole prey are not common in the literature, but data from a variety of invertebrate prey commonly fed in zoos suggest that SAA are also first limiting in these food items, followed by Arg (as determined by ideal ratios, compared to rat requirements (Finke, 2001),

Whole vertebrate prey may provide a better AA balance for zoo carnivores compared with meats or insects, but few published data exist. Limited data on rat AA composition was found in the literature (Table 4, first 3 data columns), demonstrating differences in AA content with age (Williams et al., 1953). In this instance, rats were captive-reared, and gastrointestinal (GIT) tracts were removed prior to analysis. By comparison, limited samples of free-ranging adult rodents evaluated opportunistically from another source were analyzed and found to contain a distinctly different AA pattern (Table four, last 2 data columns). In all instances, essential AA content was higher in free-ranging rodents compared to captive-reared, even lacking the potential influence of GIT contents, and more closely approached the defined ideal protein ratios of obligate carnivores. Nonetheless, even these “whole” prey still appear deficient in a majority of essential AA relative to carnivore requirements; particularly limiting may be the SAA.

One final set of analyses from captive-reared rodents used as food in zoos, analyzed with entire digestive tract intact, is found in Table 5. In this instance, differences were seen across age groups, with both adult mice and rats containing the highest and most balanced AA concentrations compared with carnivore requirements. Although SAA still appeared to be the first limiting, GIT contents contributed to a substantial increase in overall SAA nutrition – with Met + Cys:Lys ratios in gutted laboratory-reared rodents ranging from 35-42, and the same ratios in intact laboratory-reared rodents, 45-69.

The impact of the contribution of gut contents should not be discounted, and the influence of dietary amino acids in prey diets upon ultimate, and optimal, composition of whole prey for zoo carnivores should be investigated in more detail. Clearly differences exist in ideal protein (AA) ratios across species' requirements, as do concentrations in different ingredients. Determining the most suitable physiologic model (i.e. felid vs. mustelid vs. canid, etc.), for the wide variety of carnivorous zoo species (including also birds, herps, and others) is a first step in optimizing protein nutrition. Understanding that not all seemingly appropriate dietary ingredients (i.e. meat) provide optimal AA balance for carnivores, and that important nutritional differences exist depending on age, diet, and preparation of prey items, will contribute to improved nutritional status and overall health.

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Table 1. Ideal protein ratios (relative to dietary lysine (Lys) described for a variety of carnivorous species.

Amino Acid	Cat	Dog	Mink	Carnivorous Fish (European seabass, gilthead bream, turbot)
	IDEAL PROTEN RATIOS			
Lys	100	100	100	100
Arg	112	71	114	95-109
His	38	29	40	31-33
Ile	63	57	63	53-55
Leu	150	100	146	90-93
Met + Cys	100	64	80	47-58
Phe + Tyr	112	100	148	54-105
Thr	87	67	71	56-60
Trp	19	22	22	12
Val	75	75	82	58-59

Table 2. Amino acid ratios (relative to lysine (Lys)) found in a variety of domestic meats (USDA, ARS).

Amino Acid	Beef (Lean & Fat)	Chicken (Meat & Skin)	Horse Meat (lean)	Pork (Ground)	Turkey (Ground)
	AMINO ACID RATIOS (RELATIVE TO LYSINE)				
Lys	100	100	100	100	100
Arg	78	77	77	69	74
His	40	36	45	44	33
Ile	53	61	56	52	55
Leu	95	89	93	89	85
Met + Cys	43	49	42	44	42
Phe +Tyr	86	87	85	89	84
Thr	52	51	53	51	47
Trp	14	14	15	14	12
Val	58	60	61	60	56

Table 3. Amino acid ratios (relative to lysine (Lys)) found in a variety of "wild" meats (USDA, ARS).

Amino Acid	Antelope	Bison (Lean & Fat)	Boar	Guinea Fowl	Rabbit
	AMINO ACID RATIOS (RELATIVE TO LYSINE)				
Lys	100	100	100	100	100
Arg	79	76	70	78	70
His	57	34	51	36	32
Ile	46	54	49	61	54
Leu	101	100	83	89	89
Met + Cys	45	30	38	49	43
Phe + Tyr	89	89	77	88	87
Thr	55	53	48	51	51
Trp			14	14	15
Val	53	58	54	60	58

Table 4. Amino acid ratios (relative to lysine (Lys)) in whole rodents, less gastrointestinal tract contents, from different sources and age groups.

Amino Acid	Laboratory Rat Pinkie* (n=2)	Laboratory Rat Fuzzy* (n=3)	Laboratory Rat Adult* (n=6)	Free-Range Adult Rat* (n=1)	Free-Range Gopher* (n=1)
	AMINO ACID RATIOS (RELATIVE TO LYSINE)				
Lys	100	100	100	100	100
Arg	76	73	83	96	102
His	34	26	25	35	34
Ile	48	44	46	59	57
Leu	90	84	81	113	116
Met +Cys	35	46	42	56	64
Phe +Tyr	87	95	76	112	111
Thr	56	50	47	63	62
Trp	11	10	9	14	12
Val	76	73	69	75	76

*Gastrointestinal tract removed prior to analysis.

Table 5. Amino acid ratios (relative to lysine (Lys)) in whole feeder rodents.

Amino Acid	Pinkie Mouse (n=3)	Fuzzy Mouse (n=9)	Adult Mouse (n=2)	Adult Rat (n=2)
	AMINO ACID RATIOS (RELATIVE TO LYSINE)			
Lys	100	100	100	100
Arg	78	86	102	118
His	32	32	39	40
Ile	57	58	68	69
Leu	113	114	132	132
Met +Cys	45	52	68	69
Phe +Tyr	112	113	137	140
Thr	64	59	71	74
Trp	13	12	20	16
Val	69	73	88	80