Trace Element Intake Of Cercopithecinae

Winfried Arnhold[1]*, M. Anke[2], G. Krische[3] and S. Goebel[4]

[1]*AGROTEX-Chemical Inc., Pirna Germany*
[2]*Biological-Pharmaceutic Faculty, Institute for Nutrition and Environment, Friedrich Schiller University, Jena, Germany*
[3]*Fritz-Austel-Str. 100, Leipzig, Germany*
[4]*Institute for Transfusional Medicine, Leipzig University, Leipzig, Germany*

The Fe, Zn, Cu, Mn and Mo intake was determined in 5 species of Cercopithecinae kept in captivity. The feed dry matter contained up to three times higher concentrations of trace elements compared to humans' mixed and vegetarian diets. Although the mean body mass of the animals only amounted to 8% of the body mass of humans, they had a mean daily dry matter intake of 16 – 42% and a mean daily trace element intake of 18 – 128% of that of humans. However, when the daily trace element intake was related to the metabolic body mass, up to 9 times higher concentration of trace elements was found in the diet of Cercopithecinae compared to the diet of humans. Since the animals were clinically healthy and since the reproduction was not disturbed, a mean content of 60 mg Fe, 25 mg Zn, 6 mg Cu, 15 mg Mn and 0.4 mg Mo/kg feed dry matter is regarded as meeting the requirement.

Key words: mineral intake; Fe; Zn; Cu; Mn; Mo; guenon; lion-tailed macaque

INTRODUCTION

Due to changed biotopes or poaching, many Cercopithecinae kept in captivity are seriously endangered in their natural habitats. Apart from the characteristic keeping of the species, the breeding management, and veterinarian prophylaxis, their nutrition is an essential factor for the successes or losses of breeding and keeping. The sufficient supply of nutrients, vitamins and minerals does not only guarantee the survival of the wild animals, it also takes an essential effect on their performance and immune defence. Due to hardly known comparative data, the analysis of the trace element supply of Cercopithecinae has become necessary. Comprehensive investigations into the trace element

intake of humans allowed the comparison of the results registered in Cercopithecinae with the trace element intake of people with mixed diets and vegetarians [Anke et al. 1996, Röhrig 1997]. In the following, the results on the Fe, Zn, Cu, Mn and Mo intake are presented.

MATERIALS AND METHODS

The trace element intake was determined in 24 clinically healthy individuals of 5 species of Cerco-pithecinae kept in 8 groups in the Zoo Leipzig (Table 1). The animals were given 4 meals every day.

Following the duplicate method, quantitatively and qualitatively identical samples of the offered feed as well as feed residues were registered (n = 7 per group) on 7 successive days. Thus, it was possible to determine the consumption of the different kinds of feed and the trace element intake of these species. After dry ashing at 450 ºC the trace elements were determined with ICP-OES.

RESULTS

The daily trace element intake of monkeys and humans is considerably influenced by the dry matter consumption. There were significant differences between groups (Table 2). With 122 g, lion tailed macaques took in about 1.6 times more dry matter animal^{-1} day^{-1} than Diana monkeys with 77 g.

Although the mean body mass of Cercopithecinae (5.5 kg) only amounted to 8% of the body mass of humans (70 kg), they had a mean daily dry matter intake of 16 to 42% of that of humans. Related to the metabolic body mass, the daily dry matter intake of the monkey species varied between 29 and 42 g. On an average, the animals consumed approximately 2 to 3 times more dry matter kg$^{0.75\ -1}$ body mass of humans with mixed diet and 1.5 to 2 times more in comparison to vegetarians since the latter have a significantly higher dry matter intake than people with mixed diets.

The mean Fe content of the monkeys' feed dry matter varied between 64 and 78 mg Fe kg^{-1}, and was about 2.5 to 3.5 times higher than the Fe content consumed by humans with mixed and vegetarian diet (Table 3). Although there were significant differences between the groups of monkeys and humans, the daily Fe intake remained in the same range. However, the differences became obvious when the Fe intake was related to the metabolic body mass.

The zinc content of the feed dry matter did not differ between the animal groups and was only 10 mg Zn kg^{-1} dry matter higher than in human diets (Table 4). That's why the differences of the Zn intake day^{-1} and kg $^{0.75\ -1}$ between monkeys and humans on one hand and between humans with mixed and vegetarian diet on the other hand were mainly influenced by the difference in dry matter intake.

Contrary to Fe and Zn, the food dry matter of the vegetarian contained more Cu (Table 5) and Mn (Table 6) as compared to humans with a mixed diet, because the plant components of the diet had higher Cu and Mn concentrations

than animal products. The rations of the monkeys consist of plant material to more than 90%. That's why the feed dry matter contained about 2.5 times more Cu and Mn than the mixed diet of humans. Whereas the Cu intake per day differed among the Cercopithecinae the differences per kg metabolic body mass remained insignificant. Due to the significantly different dry matter intake of the animal species the Mn intake differed also significantly (Table 6).

The Mo content of the feed dry matter of monkey varied between 400 and 500 g kg^{-1} and contained similarly high Mo amounts as the food dry matter of vegetarian (Table 7). Due to the higher Mo concentration in plant material, the feed dry matter of Cercopithecinae was significantly higher than the mixed diet of humans [Holzinger, 1999].

DISCUSSION

The current recommendations for selected dietary trace nutrient concentrations for old world monkeys are: 200 mg Fe, 11.1 mg Zn, and 44.4 mg Mn per kg feed dry matter [NRC, 1978]. The trace element content of the ration dry matter taken in by the species of Cercopithecinae did not reach these recommendations. However, the mean daily trace element intake of humans met their requirement [NRC, 1989; Sandström, 1989; WHO, 1996]. Related to the metabolic body mass the monkeys took in about 1.7 to 9 more of the investigated trace elements than human. Since all examined animals were clinically healthy and since the reproduction was not disturbed, a mean content of 60 mg Fe, 25 mg Zn, 6 mg Cu, 15 mg Mn and 0.4 mg Mo kg^{-1} feed dry matter is regarded as meeting the requirement of long-tailed monkeys and lion tailed macaques. The consumed dry matter of the Cercopithecinae in the zoo mainly contained plant components (47% fruit, 9% vegetables, 42% grains and cereal products), 2% of the rations were of animal origin. Tea and milk were offered additionally. As was shown by outdoor observations and information from other types of keeping the rations for Cercopithecinae should contain most different components [Hohmann 1988, Kaumanns et al. 1988].

REFERENCES

Anke M, Müller M, Arnhold W, Glei M, Illing-Günther H, Drobner C, Seifert M, Röhrig B. 1996. Problems of the trace and ultra trace element supply of humans in Europe. In: Zeno G, Petru D, editors. Metal Elements in Environment, Biology and Medicine. 2nd Internat. Symposium Timisoara. p 15-34.

[WHO] World Health Organization. 1996. Trace element in Human Nutrition and Health. Geneva, Switzerland: WHO.

Hohmann G. 1988. Freilandbeobachtungen an Bartaffen (*Macaca silenus*). Zschr Kölner Zoo 31: 47-56

Holzinger S. 1999. Die Molybdänversorgung des Menschen unter Berücksichtigung verschiedener Ernährungsformen [dissertation]. Jena: Friedrich-Schiller-University.

Kaumanns W, Wilde J, Schwibbe M, Hindahl J, Klensang H. 1988. Zur Haltung von Bartaffen (*Macaca silenus*). Zschr Kölner Zoo. 31: 87-106

[NRC] National Research Council. 1978. Nutrient Requirements of Nonhuman Primates. Washington, DC: National Academy Press.

[NRC] National Research Council. 1989. Recommended Dietary Allowances 9, National Acadamy of Sciences, Washington, D.C.

Röhrig B. 1997. Der Zink- und Kupfergehalt von Lebensmitteln aus ökologischem Anbau und der Zink- und Kupferverzehr erwachsener Vegetarier. (dissertation). Jena: Friedrich-Schiller-University.

Sandström, B. 1989. Zinc requirement. Solicited paper for FAO/WHO/IAEA. Expert Consultation on „Trace Element in Human Nutrition". WHO Geneva.

TABLE 1. Species, number of animals, and mean body mass of Cercopithecinae included in study

Species	Number of Animals		Mean Body Mass (kg)
	Adult (n)	Juvenile (n)	
DeBrazza Guenon (*Cercopithecus neglectus*)	4	4	6.1
Campbell´s Guenon (*Cercopithecus campelli*)	2	1	3.5
Diana Monkey (*Cercopithecus diana*)	2	1	5.3
Hamlyn´s Guenon (*Cercopithecus hamlyni*)	2	2	4.2
Lion tailed Macaque (*Macaca silenus*)	4	2	6.7

TABLE 2. Dry matter intake in Cercopithecinae in comparison to humans (g day^{-1} and g kg $^{0.75\ -1}$ body mass)

Species		dry matter intake			
		day^{-1}		kg $^{0.75-1}$ body mass	
		Mean	SD	mean	SD
Cercopithecinae					
DeBrazza Guenon		105	21	38	11
Hamlyn´s Guenon		102	26	33	14
Diana Monkey		77	14	29	5.4
C. Guenon		83	16	42	7.6
L. tailed Macaque		122	35	38	5.7
Human					
Mixed diet	male	364	117	14	4.8
	women	293	87	13	4.7
Vegetarian	male	479	171	20	7.1
diet,	women	390	90	19	4.8
Fp Cercopithecinae		< 0.001		< 0.01	
Fp together		< 0.001		< 0.001	
Cercopithecinae : human (%)		16 – 42		145 – 323	

TABLE 3. The iron content of feed and food dry matter and the iron intake in Cercopithecinae in comparison to humans

Species		Fe Content		Fe Intake			
		mg kg^{-1} dry matter		mg day^{-1}		mg $kg^{0.75\ -1}$ body mass	
		mean	SD	mean	SD	mean	SD
Cercopithecinae							
DeBrazza Guenon		76	25	7.3	1.5	2.6	0.50
Hamlyn´s Guenon		78	8.6	7.8	2.1	3.1	0.75
Diana Monkey		65	9.4	4.8	0.73	1.8	0.27
C. Guenon		64	6.7	5.3	0.84	2.7	0.43
L. tailed Macaque		74	24	9.1	4.1	2.9	1.4
Human							
Mixed diet	male	24	11	8.9	4.8	0.33	0.18
	women	24	11	7.1	3.7	0.33	0.17
Vegeta-	male	22	7.8	10	4.4	0.37	0.16
rian diet	women	24	14	9.5	5.4	0.44	0.25
Fp Cercopithecinae			< 0.05		< 0.001		< 0.01
Fp together			< 0.001		< 0.001		< 0.001
Cercop. : Human (%)			267 – 355		48 - 128		409 – 939

TABLE 4. The zinc content of feed and food dry matter and the zinc intake in Cercopithecinae in comparison to humans

Species		Zn Content		Zn Intake			
		mg kg^{-1} dry matter		mg day^{-1}		mg $kg^{0.75\ -1}$ body mass	
		mean	SD	mean	SD	mean	SD
Cercopithecinae							
DeBrazza Guenon		34	18	2.9	0.66	1.0	0.19
Hamlyn´s Guenon		32	3.2	3.2	0.92	1.3	0.31
Diana Monkey		30	2.3	2.2	0.38	0.83	0.14
C. Guenon		28	3.0	2.3	0.48	1.2	0.24
L tailed Macaque		31	11	3.8	1.8	1.2	0.67
Human							
Mixed	male	20	5.0	7.5	3.1	0.28	0.12
diet	women	21	7.4	6.0	2.8	0.28	0.13
Vegeta-	male	20	5.6	9.5	3.9	0.36	0.15
rian diet	women	22	5.1	8.6	2.6	0.40	0.12
Fp			> 0.05		< 0.001		< 0.01
Cercopithecinae							
Fp together			> 0.05		< 0.001		< 0.001
Cercop. : Human (%)			136 - 170		23 – 61		208 – 464

TABLE 5. The copper content of feed and food dry matter and the copper intake in Cercopithecinae in comparison to humans

Species	Cu Content		Cu Intake			
	mg kg^{-1} Dry matter		mg day^{-1}		ug $kg^{0.75\ -1}$ body mass	
	mean	SD	mean	SD	mean	SD
Cercopithecinae						
DeBrazza Guenon	8.4	2.3	0.82	0.17	297	56
Hamlyn´s Guenon	7.2	0.70	0.74	0.20	291	71
Diana Monkey	8.7	2.8	0.66	0.30	247	111
C. Guenon	6.7	0.58	0.56	0.13	287	65
L. tailed Macaque	7.9	0.71	0.99	0.48	309	156
Human						
Mixed male	3.2	1.4	1.2	0.67	45	25
diet women	3.7	2.2	1.1	0.86	51	40
Vegeta- male	4.4	1.7	2.1	1.0	79	37
rian diet women	4.1	1.3	1.6	0.57	74	26
Fp		> 0.05		< 0.01		> 0.05
Cercopithecinae						
Fp together		< 0.001		< 0.001		< 0.001
Cercop. : Human (%)		152 - 272		27 - 90		313 – 687

TABLE 6. The manganese content of feed and food dry matter and the manganese intake in Cercopithecinae in comparison to humans

Species		Mn Content		Mn Intake			
		mg kg^{-1} Dry matter		mg day^{-1}		ug $kg^{0.75\ -1}$ body mass	
		mean	SD	mean	SD	mean	SD
Cercopithecinae							
DeBrazza Guenon		18	2.4	1.9	0.44	684	131
Hamlyn´s Guenon		19	3.9	1.8	0.49	733	170
Diana Monkey		19	2.1	1.4	0.25	515	92
C. Guenon		18	1.9	1.5	0.36	764	186
L. tailed Macaque		18	3.5	2.2	0.68	685	216
Human							
Mixed	male	7.6	2.7	2.7	1.2	101	45
diet	women	8.2	3.5	2.4	1.2	111	56
Vegeta-	male	12	5.1	5.9	3.9	221	146
rian diet	women	14	5.2	5.5	2.1	255	97
Fp Cercopithecinae		> 0.05		< 0.01		< 0.05	
Fp together		< 0.001		< 0.001		< 0.001	
Cercop. : Human (%)		129 – 250		24 – 92		202 – 756	

TABLE 7. The molybdenum content of feed and food dry matter and the molybdenum intake in Cercopithecinae in comparison to humans

Species	Mo Content		Mo Intake			
	ug kg^{-1} Dry matter		ug day^{-1}		ug $kg^{0.75\ -1}$ body mass	
	mean	SD	mean	SD	Mean	SD
Cercopithecinae						
DeBrazza Guenon	446	81	47	12	17	3.6
Hamlyn´s Guenon	436	69	44	11	17	4.2
Diana Monkey	500	153	39	17	15	6.4
C. Guenon	402	36	33	6.2	17	3.2
L. tailed Macaque	422	115	50	13	16	4.1
Human						
Mixed male	268	137	95	52	3.6	2.1
diet women	291	220	85	84	3.9	3.7
Vegeta- male	385	167	170	92	7.2	3.7
rian diet women	471	331	179	131	8.8	6.8
Fp		> 0.05		< 0.01		> 0.05
Cercopithecinae						
Fp together		< 0.001		< 0.001		< 0.001
Cercop. : Human (%)		85 - 187		18 – 59		170 – 472