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Feeding Asian and African elephants *Elephas maximus* and *Loxodonta africana* in captivity — Source link

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Feeding Asian and African elephants *Elephas maximus* and *Loxodonta africana* in captivity

Abstract

Considering the low rate of reproduction in Asian elephants *Elephas maximus* and African elephants *Loxodonta africana* in captivity, and the critical status of the size of the captive population, nutrition plays an important role in the captive management of elephants. This paper highlights two major reviews of the subject but emphasizes those aspects of the feeding regime that seem of particular importance and practical relevance. Obesity and colic are of major concern and offering good-quality hay as a staple diet item over an extended period of the day is the most important recognized prophylactic measure against these conditions. Fruits, cereals, bread or pelleted feeds are not recommended owing to their high financial cost and contribution to obesity, respectively. The use of pelleted compound feeds may only be warranted to address mineral or vitamin deficiencies in the hay supplied to elephants.

<SLUG>ZYBA 000\

<RH>REVIEW: ELEPHANT FEEDING IN CAPTIVITY\

<LH>ELEPHANTS AND RHINOCEROS\

<CATCH>Int. Zoo Yb. (2006) 40:© The Zoological Society of London\

5 <HA>Feeding Asian and African elephants\

<HB>*Elephas maximus* and *Loxodonta africana*\

<HA>in captivity\

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<AB>Considering the low rate of reproduction in Asian elephants *Elephas maximus*

and African elephants *Loxodonta africana* in captivity, and the critical status of the

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15 management of elephants. This paper highlights two major reviews of the subject but

emphasizes those aspects of the feeding regime that seem of particular importance

and practical relevance. Obesity and colic are of major concern and offering good-

quality hay as a staple diet item over an extended period of the day is the most

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and contribution to obesity, respectively. The use of pelleted comound feeds may

only be warranted to address mineral or vitamin deficiencies in the hay supplied to

elephants.\

<KW>Key-words: African elephant, Asian elephant, browse, hay, nutrition, obesity,

25 protein\

<TX1>Populations of elephants in captivity are at risk owing to their low reproductive

success (Kurt, 1999; Hildebrandt *et al.*, this volume). A knowledge of the nutritional

requirements of elephants is important in view of the occurrence of nutrition-related

diseases and welfare issues, and low reproduction rates (Löhlein, 1999). According

30 to Owen-Smith (1988), elephants belong to the group of megaherbivores and their

large body size places constraints on their feeding strategy and the type of dietary

research that can be carried out. The nutrition of elephants has been the subject of

two thorough reviews that cover a full range of studies on elephant feeding behaviour

and digestion (Dierenfeld, 1994; Ullrey *et al.*, 1997), and it is discussed again by

35 Stevenson & Walter (2005). Here, those aspects of the feeding regime of elephants

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in captivity that seem of particular importance and practical relevance are emphasized.\

The anatomy of the digestive system of an elephant roughly resembles that of a horse. Elephants are monogastric animals with a hindgut fermentation chamber,
40 which is surprisingly short but extremely voluminous (Shoshani *et al.*, 1982; Stevens & Hume, 1995). Microbial fermentation of plant fibre in the hindgut provides the main energy source for these animals.\

Elephants consume both grasses and browse (i. e. branches, twigs, foliage, and at
45 times selectively bark) in the wild. Isotope analyses of fossilized bones indicate that, historically, both extant elephant species (Asian elephant *Elephas maximus* and African elephant *Loxodonta africana*) were grazers and that the increasing inclusion of browse in their natural diet is a comparatively new phenomenon, the reasons for which are unclear (Cerling *et al.*, 1999). Isotopic evidence suggests that the natural diet of the Asian elephant may include a higher proportion of grass than that of the
50 African elephant (Cerling *et al.*, 1999). Yet, today, browse generally accounts for the majority of the natural diet of both species. The natural diet is characterized by a very high-fibre/cell-wall content [crude fibre 30–50% dry matter (DM), neutral detergent fibre (cell walls) 50–70% DM] and a low-to-moderate protein content (crude protein 8–12% DM) (McCullagh, 1969; Clemens & Maloiy, 1982; Van Hoven, 1982; Meissner
55 *et al.*, 1990).\

The large body size of elephants, together with their co-operative nature, facilitate nutritional studies, although it is challenging to manage the large quantities of food and faeces during such research. The digestive strategy of elephants is characterized by a surprisingly fast ingesta passage (reviewed by Löhlein *et al.*,
60 2003) and, hence, a comparatively low digestive efficiency (reviewed by Clauss, Löhlein *et al.*, 2003). Because digestive efficiency is so low intact diet items often appear in the faeces, which are sometimes re-ingested by the elephants (Sever, 1982), a behaviour that is rarely observed in the wild (Guy, 1977). Dry matter intake in adult elephants is c. 1–1.5% of body mass (Ullrey *et al.*, 1997). Growing elephants
65 appear to have a higher intake, at 2% of body mass (Clauss, Löhlein *et al.*, 2003).\

While it may appear reasonable to use known dietary requirement data for horses
(for minerals and some vitamins in particular) as feeding recommendations for elephants, the low digestive efficiency of these species precludes the use of the equations derived for domestic horses to estimate the digestible energy content of a
70 given diet for elephants.\

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<HD>DIET FORMULATION: QUANTITY AND COMPOSITION\

<TX1>In general, when thinking about formulating the diets of animals, there is a tendency to focus on the mineral and, especially, vitamin components and to overlook the most obvious and important reason for feeding: the supply of energy. In

75 many zoological institutions, elephants are obese, i. e. they display excessive amounts of fat at necropsy, or appear in a more than good body condition, [or have a body mass that significantly surpasses that of their wild conspecifics (Ange *et al.*, 2001; Hatt & Liesegang, 2001) (Plates 1 and 2). Ange et al. (2001) report an average (!) difference in body mass between captive females and published average values (African elephant: 2,800 kg; Asian elephant: 2,720 kg) of 21 % in African and 27 % in Asian elephants. Obesity is a recognized problem in human medicine and in elephants the tendencies to develop foot lesions (Csuti *et al.*, 2001) or joint problems will almost certainly be exacerbated by being overweight. Leiomyomas (benign uterus tumors that make the animal infertile) [] of the female genital tract, which are
85 frequently diagnosed in elephants (Hildebrandt & Göritz, 1995), are thought to be linked to obesity in humans (Shikora *et al.*, 1991; Sato *et al.*, 1998). Therefore, a moderate body mass (using values of free-ranging animals as guidelines) [] should be the aim of husbandry methods and the diets of overweight elephants should be reduced accordingly.\

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90 The general considerations about energy requirements outlined for rhinoceros also apply to other hindgut fermenters, such as elephants (see also Clauss & Hatt, this volume). Dietary items that deliver readily digestible energy, such as grains, low-fibre pelleted compound feeds [] and fruits, should not be given. The *ad libitum* feeding of a low-fibre, high-protein roughage source can lead to a gain in body mass, similar to
95 that seen in horses (Moore-Colyer & Longland, 2000). Roughage that is offered *ad libitum* should always have a high-fibre content (e.g. branches [], late-cut hays, oat hay/straw) and low-fibre, high-protein roughages (early-cut hays, legume hays, fresh grass) should be restricted. As the digestible energy content of diets cannot be estimated from the equations agreed for horses, the most practical approach to
100 maintaining a reasonable body condition is to weigh elephants regularly [], to judge their body condition [AUTHOR: Referee 2, point 16: do you want to add Hile et al., 1997 reference here (and in Reference list)? NO] and to adjust the amount of low-fibre components in the diet accordingly. As long as a standardized body condition score for the elephant species is missing, elephant managers should improvise in assessing the condition of their animals, noting in particular bony structures of the
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hips and spine, ideally using continuous photographic documentation. At Zurich Zoo the total amount of food offered was reduced at the same time as the fibre content of both the roughage (by mixing the usual grass hay at a ratio of 1:1 with oat hay) and the pelleted compound feed (from a crude fibre content of 11% DM to 23% DM) was increased. These measures led to a c. 10% reduction (i.e. 400 kg) in body mass in three adult female Asian elephants after 6 months, with no observed negative side effects.\

Gelöscht: diet ingredient

Gelöscht: AUTHOR: see Referee 2, point 23

Gelöscht: ?? [AUTHOR: in how many female elephants?

<HD>DIET COMPOSITION: HAY\

<TX1>The staple diet of elephants in captivity will most likely consist of grass hay, which is ideal for species adapted to eating plants high in fibre. The primary concerns are (1) the hygienic quality of the hay and (2) potential deficiencies, particularly in protein, minerals and vitamins.\

There are no prophylactic measures to guard against hay of poor hygienic quality. Every batch of hay must undergo a proper inspection and animal managers should refuse to buy hay of low hygienic status or dispose of poor-quality hay that has already been purchased. At Zurich Zoo, the hay is processed with a shaker, which not only allows the detection and removal of any foreign material but also significantly reduces the amount of dust that is thrown up when the hay is handled, either by the keepers or elephants. This reduces the risk of respiratory-tract disease, which has been described in rhinoceros (see also Clauss & Hatt, this volume). The highest standards of hygiene should be applied to the quality and storage of hay. There are standard guidelines for judging the hygiene status of hay (Ullrey, 1997) and comparable guidelines are available from regional institutes of animal nutrition.\

Nutrient deficiencies of hay can only be detected through laboratory analysis of a representative sample. These deficiencies can then be balanced out with the provision of specific supplements, such as limited amounts of pelleted compound feeds. Ideally, every batch of hay should be analysed for a set of nutrients (Ullrey, 1997) and pelleted compound feeds or mineral supplements should be provided accordingly. There are a few zoos that do this work but most institutions want recommendations for diet supplementation that can be applied without routinely analysing each batch of hay.\

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<TX2><I>Supplementation<R>[h]When choosing components to supplement a hay ration, it is necessary to consider what nutrients really need to be added to the diet.

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Bread, grains, low-fibre pellets and fruits simply add energy that could easily be

provided by offering more hay. High-fibre pellets also add energy and fibre to the diet: again, nutrients that can be provided by increasing the amount of hay offered. High-fibre pellets may be a possible dietary alternative when adequate amounts of hay cannot be provided but these pelleted compound feeds do not represent an obligatory diet item. It is essential that an adequate quantity of protein is provided in the diet, particularly for growing animals. Protein deficiency in elephants on a poor grass-hay ration has been recorded in the literature (Ullrey *et al.*, 1985) and Ange *et al.* (2001) reported that diet rations for elephants in five out of 15 zoos investigated were lower in protein [AUTHORS: could you please confirm if `were lower in protein`

is correct here? **Yes it is**. Original text said `elephant rations in five out of 15 zoos investigated to be lower than levels recommended by Ullrey *et al.* (1997).`] than the levels recommended by Ullrey *et al.* (1997). Protein in a grass-hay ration can be increased by adding a legume hay (e.g. clover or lucerne, which will simultaneously guarantee an adequate calcium content), and the addition of freshly cut grass when in season will also increase overall protein levels in the diet. Conventional pelleted food contains high proportions of energy-rich ingredients (mostly grains). The development of a supplement that could be used sparingly, comprising mostly lucerne meal, high concentrations of minerals and vitamins, and (potentially) some fat, has been suggested (see Ullrey *et al.*, 1997).\

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Gelöscht: and soy meal (as protein sources)

<HD>NON-ROUGHAGE FOOD ITEMS\

<TX1>The dietary concentrations of micronutrients recommended for horses should also be adequate for elephants (Ullrey *et al.*, 1997; Kurt, 1999; Ange *et al.*, 2001). Mineral deficiencies have rarely been reported in elephants in captivity, with the exception of a zinc deficiency (Schmidt, 1989) and several cases of a calcium deficiency (Dierenfeld, 1994). However, a survey by Ange *et al.* (2001) demonstrated that, when compared to the standards for horses, the diet for elephants in many zoos was deficient in several vitamins and minerals. The adequate use of a supplemental feed (described above) based on a ration calculation, will balance out such deficiencies.\

Reports on two cases of white-muscle disease have been published, one for an African elephant (Papas *et al.*, 1991) and one for an Asian elephant (Dolensek & Combs, 1985). The results of trials into the efficacy of alpha-tocopheryl polyethylene glycol succinate (TPGS) as a potential therapy indicated that serum levels of vitamin E in elephants respond quickly to supplementation with this form of water-soluble vitamin E but not to the conventional forms of vitamin E; this was interpreted and

marketed as a suggestion, that elephants need a vitamin supplement containing (the very expensive) TPGS. However, several long-term studies have shown that eventually serum vitamin E levels of elephants do respond appropriately to supplementation with conventional forms of vitamin E (Dierenfeld & Dolensek, 1988; reviewed in Ullrey *et al.*, 1997; Dierenfeld, 1999 []). Free-ranging elephants naturally seem to have lower plasma vitamin E levels than domestic herbivores (Savage *et al.*, 1999). Dietary vitamin E levels of 100–200 IU/kg DM are likely to be sufficient. Single plasma samples are not sufficient to evaluate the vitamin E status of an elephant as these levels may be subject to a one-and-a-half to twofold variation in plasma alpha-tocopherol concentrations between elephants of the same age class, eating the same diet (Shrestha *et al.*, 1998). Considering that serum vitamin E levels may show such variation, further research into the supplementation of vitamin E in elephants is warranted.\

Gelöscht: , suggesting

Clauss, Wang *et al.*, (2003) indicated that a deficiency in polyunsaturated fatty acids (PUFAs) could be relevant to the occurrence of atherosclerosis (plaque formation on the inside of the arterial wall) [] and could also have a negative effect on sperm quality and on reproductive performance. Generally, the diet of herbivores in captivity is higher in saturated fatty acids, monounsaturates and n-6 polyunsaturates, and lower in n-3 polyunsaturates, than their natural diet (Grant *et al.*, 2002). Elephants in captivity appear to have lower proportions of PUFAs and, for several lipid fractions, a higher n-6:n-3 ratio than their counterparts on more natural diets (Clauss, Wang *et al.*, 2003). Recommendations on the formulation of potential pelleted compound feeds in this respect are given by Clauss & Hatt (this volume).\

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Fruits and vegetables can generally be regarded as harmless items that are, for their DM and nutrient content, extremely expensive (Oftedal & Allen, 1996). There are two reports of elephants choking on unchewed fruits (Kodituwakku *et al.*, 1961; Wood, 1992) and there is no scientific basis for including large amounts of fruit and vegetable produce in elephant diets.\

Gelöscht: Any concentrated supplement for herbivores should potentially contain a source of n-3 PUFAs

High proportions of non-roughage food in general should be avoided. Several authors suggest that problems observed with molar teeth in elephants are a result of a diet that does not cause enough abrasion (Flower, 1943; Seitz, 1967; Heymann, 1969; Short, 1969; Reichard *et al.*, 1982).\

Gelöscht: . However, this consideration requires further research

Colic is frequently observed in elephants in captivity (Salzert, 1976; Rüedi, 1995). The continuous stimulation of gut peristalsis resulting from a constant supply of high-fibre roughage is the most important dietary prophylactic measure. Ingestion of large

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amounts of low-fibre food, such as fruits, bread, pellets and concentrates, at any one time should be avoided, as this can lead to colic, enteritis or symptoms resembling grain overload in horses (Vasantha & Yathiraj, 1990; Dierenfeld, 1994; Kulka *et al.*, 2002). The ingestion of foreign bodies, sand or mouldy hay may also lead to colic (pers. obs).\

<HD>ENRICHMENT\

<TX1>The few studies that have been carried out with elephants seem to indicate that they benefit if they are provided with food items that require complex processing [], such as using the trunk to break off smaller twigs from larger branches, (Stoinski *et al.*, 2000). Elephants also seem to benefit from receiving their diet ration as one large bulk delivery, rather than several smaller meals (Morimura & Ueno, 1999). Hiding individual food items did not produce any beneficial effect (Wiedenmayer, 1998).\

The addition of twigs and branches to the diet is important for dietary fibre content, and especially for the behaviour as these items often require more complex

manipulation with the trunk than hay []. Furthermore, dental problems (with molars) appear to occur more frequently if an inadequate amount of browse is provided, [] (Dierenfeld, 1994). As the supply of browse is limited [] in many zoological institutions, and several other species might be higher on the priority list to receive it, elephants could routinely be offered leftover branches that are not eaten by other animals if disease transmission appears unlikely.\

<HD>CONCLUSION\

<TX1>A balanced diet is a prerequisite for good health, longevity and reproductive success. Considering the low rate of reproduction of elephants in captivity and the critical status of the captive-population size, nutrition plays an important role in the captive-management of these species. Nutrition-related diseases appear to be an issue, although dietary deficiencies seem to play only a minor role. Overfeeding and qualitatively unsatisfactory (low-fibre) diets result in obese animals, as well as the more frequent occurrence of tooth disorders and colic, respectively.\

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Gelöscht: browse/branches

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please elaborate on the
behaviour

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no rocks or roots around the
enclosure to promote molar
abrasion and oral health

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Plate 1. Captive Asian elephants *Elephas maximus* showing marked obesity.

385 [AUTHORS: please provide the copyright credit for this photograph?]\

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Plate 2. Wild Asian elephant at Yala-National Park, Sri Lanka, during vegetation period. Photograph reproduced with kind permission of B. Aeschbach. [AUTHOR: do

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