

Zoo Animal Nutrition I

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Nutrition Research in Zoo Animals

Abstract

This paper presents an overview of aspects that should be considered when planning and carrying out nutrition research with zoo animals. Zoo animal nutrition research in the narrow sense comprises studies of the digestive strategies of zoo animals. In the broader sense it involves studies such as comparative anatomy and physiology, behavioural studies, and studies on foodstuff analyses. Zoo animals are considerably more difficult subjects as compared with traditional experiments designed with domestic, and particularly laboratory animals. The available number of animals is usually small and their heterogeneity large. Options are discussed to overcome this disadvantage. The following aspects for zoo animal nutrition research are discussed: formulating a problem, developing a research design, setting out alternative hypotheses, appropriate sampling and data collection techniques, and data analysis. As a conclusion there is encouragement for more rigorously designed scientific projects incorporating a multidisciplinary approach, such as the involvement of universities. Finally, the need for publishing results of nutrition studies in scientific journals is emphasised.

Keywords

hypothesis, small n, data analysis, diet

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Dietary Husbandry of Commonly Exhibited Terrestrial Invertebrates

Abstract

*The determination of feeding requirements for invertebrates in captivity, and successful methods for meeting them, is based on knowledge of the animal's natural history, mouthparts, and gut structure. While artificial diets have been used for decades for mass rearing of insects required in academic and industrial studies, targeted development of artificial diets for exhibit species or those species in conservation programs has rarely been investigated. Furthermore, studies of interactions of feeding regimes (amounts and frequencies) with environmental factors necessary for proper growth and development have only been sporadically documented for the species of interest. "Natural diets" are thus most commonly employed for captive populations. Invertebrate (especially arthropod) diets encompass plants, blood, carrion, wood, seeds, nectar, pollen, and other invertebrates. Feeding strategies can be divided into five major categories, with examples and nutrient considerations from each to be highlighted: 1) solid carnivory (mantids, dragonflies, scorpions, and burying beetles), 2) liquid carnivory (spiders and assassin bugs), 3) omnivory (cockroaches), 4) solid herbivory (stick insects, caterpillars, grasshoppers, and *Partula* snails), and 5) liquid herbivory (aphids and butterflies).*

Keywords

arthropods, butterflies, insects, spiders, scorpions

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P. Zwart

Nutrition of Chelonians

Abstract

A review is presented of the most important aspects of nutrition of tortoises and terrapins, including a short survey of the ingestion of non-energetic substances such as stones or sand. This is followed by a presentation of elements in nutrition such as undernutrition and overfeeding concerning proteins, fatty substances and carbohydrates. Deficiencies in the vitamins A, D3, B1, as well as overdosing in Vitamin A and D3 are discussed. Special attention is given to aspects of calcium deficiency. Therapies are included.

Keywords

deficiency, mineral, energy, Vitamin A, Vitamin D3, Vitamin B1, calcium

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Examination of the digestibility of Ca, Mg and P in four captive born juvenile Galapagos giant tortoises (*Geochelone [elephantopus] nigra*)

Abstract

Many diets of zoo animals are low in calcium or have a poor calcium: phosphorus (Ca:P) ratio. To achieve optimal growth, including a healthy skeleton and a powerful shield, a well-balanced supply of calcium and phosphorus is important. The purpose of this study was to evaluate the digestibility of the diet fed at Zurich Zoo with special emphasis on the digestibility of minerals. Four captive born juvenile Galapagos giant tortoises at Zurich Zoo were used. The animals had an average weight of 2.1 ± 1.0 kg. They were housed inside at a mean temperature of 23°C, at 65 % humidity, and were exposed to a 12h light: 12h dark day including exposition to UV light. To evaluate the transit time of the digesta, carmine red (approximately 66 mg per kg BW) was given once in the food. After the transit time was estimated (8–18 days), the animals were fed the same diet, which consisted of vegetables, herbs and a mixture of different Ca sources. Daily mixed fecal samples of all tortoises were collected from day 8 to day 18. A Weender analysis was performed and the HCl-insoluble ash was used as endogenous indicator for the determination of the apparent digestibility. The energy content of the mixed feedstuffs was 15.23 MJ/kg dry matter; crude fiber content was 131 g/kg dry matter; protein content 194 g/kg dry matter. The Ca content of the above-described foodstuffs was 5.72 % in dry matter and the Ca:P ratio in the food was 14 : 1. The digestibility of Ca was 61 %. The other examined minerals, Mg and P, had a digestibility of 62 % and 79 %, respectively.

Keywords

Calcium, magnesium, phosphorus, tortoises, nutrition

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D.C. Houston, A. Fidgett

What are the nutritional requirements for making a good bird egg?

Abstract

There is increasing evidence from field studies that egg production can be a demanding process for birds. For many wild birds female body condition before the start of laying may be an important determinant of egg production, and for some species muscle proteins in the female body are broken down to assist with egg protein production, and the muscle condition of the female before laying influences the size of her clutch. The physiological state of the female is also probably important in determining other aspects of egg quality, and identifying optimum nutrition for captive birds in the months before the start of breeding is probably as important factor determining breeding success.

Keywords

Nutrition, egg quality, egg production

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D. C. Houston

Digestion strategies in meat and fish eating birds

Abstract

Meat and fish eating birds differ in their digestive efficiency, their speed of digestion and in the length of their digestive tract. It is suggested that the predatory behaviour shown by a species influence the digestive strategy it has evolved. In birds of prey those species which require rapid acceleration to capture their prey have evolved comparatively short guts, and poor digestive efficiency, because the reduced body mass that this causes enables them to achieve a higher rate of prey capture. Those species which scavenge or do not require rapid acceleration have longer guts and higher digestive efficiency. The same effects are found in fish eating birds, but there are other factors also involved. Short gut species are forced to be specialised in the choice of prey items taken, which must be of high energy content to compensate for their comparatively poor digestive efficiency.

Keywords

digestion, fish eating birds, birds of prey.

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U. Gansloßer, D.B. Croft

Diet selection, foraging ecology and social relationships in Macropodoidea (Kangaroos, Wallabies and Rat-kangaroos)

Abstract

The Macropodoidea are members of two families of marsupials ranging in size from 850 g to 90 kg, and in habitat from rainforest dwelling arboreal treekangaroos to arid zone adapted kangaroos. Their morphophysiological adaptations to foraging and nutrition are reviewed with respect to skull morphology, dentition, digestive anatomy, sexual dimorphism in size and weight, and energetics of locomotion. We then describe results of case studies, both field and experimental, testing hypotheses on foraging behaviour derived from these adaptations. The case studies relate to intraspecific size differences, food search strategies, adaptations to decreasing food quality, spatially clumped feeding situations, and effects of handrearing on foraging. We propose a number of changes in macropodoid feeding regimes based on these results.

Keywords

Optimal Foraging theory, gastro-intestinal tract, dentition, locomotor energetics, sex differences in feeding

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Intake and Diet Digestibility in Three Species of Captive Pteropodid Bats

Abstract

*Dietary intake and digestibility were compared in females of 3 species of captive fruit bats (*Pteropus vampyrus*, *P. hypomelanus*, and *P. pumilus*) fed the same diet. Daily total food intake averaged 28 % of body mass on an as-fed basis, or 7 % on a dry matter (DM) basis. Dietary leftovers contained higher concentrations of protein and fat than the diet offered, and lower levels of soluble carbohydrates (CHO), suggesting some nutrient selectivity even in an apparently homogenous diet. Digestibility of DM (89 to 94 %), protein (76 to 91 %), crude fat (51 to 58 %), and water-soluble CHO (95 to 98 %) did not vary among species, indicating that *P. hypomelanus* may provide a suitable physiological model for nutrition studies of other, more endangered, fruit bats.*

Keywords

nutrition, Chiroptera, fruit bats

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Nutrition of Old World Fruit Bats in Captivity: Diet Studies of Livingstone's Fruit Bats *Pteropus livingstonii*

Abstract

*Fruit bats of the sub-order Megachiroptera and family Pteropodidae are being increasingly kept and bred in captivity. However, there remains relatively little known about the adequacy of the diets that are fed to them. In addition, the combination of reduced exercise and a plentiful food supply result in captive bats being generally heavier than their wild counterparts. The nutrition and feeding habits of captive Livingstone's fruit bats *Pteropus livingstonii* were studied at Jersey Zoo, with the aim of improving their feeding regime. First, feeding behavior was examined to try and explain why some bats were much heavier than others. Significant variation in time spent feeding and the utilization of feeding sites was revealed. The bats' daily diet was then evaluated. The amount and the number of different food items were found to vary considerably from day to day. Nutritional breakdowns of foods were obtained and the available literature on fruit bat nutrition was used to compare known nutrient and energy requirements with the levels presented. A new diet, with a reduced daily diversity of food items was proposed, to try and minimize the effect of individual preferences and social status on nutrition. This diet was balanced over a weekly period and made nutritionally comparable to the former one, as no health problems, other than possibly obesity, had so far been linked to nutrition. Trials of the modified diet gave an indication of dietary preferences, for example, acid fruits were found to be the least preferred foods. The diet was then further altered to take into account these preferences, distributing the most preferred and disliked foods more evenly throughout the week.*

Keywords

nutrition, fruit bat, Chiroptera, captive management, diet, feeding

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Primate nutrition: towards an integrated approach.

Abstract

This paper intends to assess the status of primate nutrition in European zoos and provides suggestions on how to improve the situation. It refers to a study that analysed around 200 diets (plans) used for 50 primate species in 26 genera with reference to foodstuffs and nutrients. The results revealed that primates in zoos are often fed without reference to generally accepted, science-based standards. Considerable differences were found between diets for the same species in different zoos. Diets for different species within a zoo, however, tend to be rather similar. It is suggested that a more systematic approach towards primate nutrition and more co-operation are required. Feeding is regarded as a complex functional system, which includes a number of physiological and behavioural subsystems. The development of appropriate concepts for primate nutrition must start at this point. Food intake in primates is influenced by ecological, individual, and, in particular, social factors. Primate nutrition should integrate data from the relevant biological disciplines and apply this to all aspects of the captive situation of a primate species.

Keywords

Primate nutrition, feeding ecology, diets, requirements

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Feeding Fussy Folivores: Nutrition of Gentle Lemurs

Abstract

The genus *Haplemur* comprises five currently-recognized taxa, three of which are critically endangered. They range in size from 700–2300 g, but most weigh less than 1500 g. All members of this genus are specialist feeders on the monocot family Poaceae. The forest lemurs *Haplemur g. griseus*, *H. g. occidentalis*, *H. aureus* and *H. simus* all spend > 85 % of their feeding time on bamboos, whereas the marsh dweller *H. g. alaotrensis* spends > 95 % of feeding time on papyrus, reeds and surface grasses. All are highly selective, choosing shoots, leaf bases, growing tips and pith. These lemurs can thus be classed as highly selective and almost exclusively folivorous. All the *Haplemur* species are represented in captivity, although most (cf. *H. g. alaotrensis*) only in small numbers. However, folivores are generally difficult to maintain in captivity, because plant material is extremely variable in its nutritional composition, and regular quantities of appropriate forage may be difficult to obtain. Studies of nutrition in both wild and captive *Haplemur* indicate that these lemurs have a typically folivorous diet containing high protein and fiber and relatively low energy. It is unclear how these small lemurs can sustain themselves on a completely folivorous diet. Constraints of low energy and low fiber digestibility could theoretically be met by: reduction in BMR, specializations of the digestive tract, and behavioral adaptation. The existence of these strategies in *Haplemur* is reviewed and recent work from field studies on *H. g. alaotrensis* suggests several implications for captive management: e. g., the diet should be high in fiber to maintain gut function; pelleted diet should be leaf-eater/folivore rather than a primate pellet; large amounts of forage should be provided to allow the lemurs to be selective; and sufficient quantities of fibrous food should be given to allow for night-time feeding.

Keywords

Haplemur, folivore, nutrition, diet, fiber, specialist, conservation

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Feeding Behaviour in Two Captive Groups of Black-and-White Ruffed Lemurs (*Varecia v. variegata*), KERR 1792

Abstract

*In captive Black-and-white ruffed lemurs (*Varecia v. variegata*), obesity as well as an increase in the number of infants per litter are assumed to be feeding-related problems. In this study, the feeding behaviour was examined in addition to the amount and composition of the consumed food in two captive groups of ruffed lemurs. Special regard was given to energy intake. Additionally, in a pilotstudy, it was tested in two individuals whether they preferred a high concentration of sugar to a lower one. In another pilot-study, digesta passage rates were measured for different foodstuffs. The results revealed a high energy intake in the studied individuals compared to their calculated maintenance energy requirement, especially in adult females. The animals preferred feeds with higher concentrations of sugar. Digesta passage rates were short. Given that the feeding schedule analysed here was representative of those used in other institutions, many ruffed lemurs were likely to be overfed. An important precondition for obesity and an increase in litter size, would therefore be evident.*

Keywords

*Black-and-white ruffed lemurs, *Varecia v. variegata*, obesity, litter size, diet, energy intake, digesta passage rates*

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Nutrition Research on New World Monkeys at Jersey Zoo

Abstract

*Problems potentially related to nutrition that have arisen in the collection of New World primates at Jersey Zoo are described. A study of the nutrition of Geoffroy's marmosets (*Callithrix geoffroyi*), initiated because of health problems and high infant mortality, suggested that the diet may have been low in calcium and protein. Alterations were accordingly made to the diet: gum arabic is now provided on a daily basis for all *Callithrix* in the collection, and the proportion of insects in the diet has been increased. Palatability of different concentrations of gum has been investigated to assess the most cost-effective way of maximising gum intake. The diet of pied tamarins (*Saguinus bicolor*) in the collection has also been modified because of several health and related problems: chronic diarrhoea and "wasting"; frequent observations of coprophagy; the relatively common occurrence of premature and stillbirths; and locomotor problems in young pied tamarins that have had to be confined indoors despite dietary supplementation. These problems suggested that this species has high protein and vitamin D3 requirements. Citrus fruits and other potential irritants have been eliminated from their diet, they are supplied with extra insects daily, and gum Arabic is given regularly. Increasing protein is difficult, as a study on the palatability of several types of primate pellet showed that the pellets designed specifically for New World primates are not the most palatable. Approaches to increasing palatability and intake are described, included the use of different flavourings, and the effect of reducing the amount of fruit presented on pellet intake.*

Keywords

marmoset, tamarin, diet, palatability, protein, calcium, vitamin D3

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Effects of dietary changes on the behavior and fecal consistency of three captive eastern lowland gorillas (*Gorilla gorilla graueri*) at the Royal Zoological Society of Antwerp

Abstract

*An important problem with the eastern lowland gorillas (*Gorilla gorilla graueri*) at the Royal Zoological Society of Antwerp was regular re-occurrence of serious diarrhea. Examination of fresh stool samples revealed the presence of large numbers of *Entamoeba* sp. and *Trichomonas* sp. Because medical treatment was not always successful, it was hypothesized that this problem might in part be attributed to the animals' diet. Behavioral observations were carried out to quantify the daily intake of food and the baseline activity budget for each animal. The daily consumed diet was analyzed using the Animal Nutritionist program, and compared with the diet of wild gorillas and the SSP recommendations for captive animals. A new diet, containing less fruit and more green leafy vegetables, other vegetables, leaves and branches than the old diet, was introduced. In comparison to the baseline observations, observations of the situation with the new diet revealed an almost absence of diarrhea in the 30 year old female and the 41 year old male. In contrast, the eight year old female showed only a slight reduction in the occurrence of diarrhea. For this animal the occurrence of diarrhea is related to other factors in addition to diet, one of which may be stress. Observations further revealed a significant increase in food searching behaviour for the two females and time spent eating for the male, as well as a significant decrease in the time spent resting by the male.*

Keywords

nutrition, feeding, behavior, diarrhea, primate

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A review of foraging niches in Rodents and their implications for captive management

Abstract

*Of all the Mammalian Orders, the Order Rodentia contains the largest number of mammal species. The rodents comprise a total of 2021 species, which represents 43.7 % of all mammals. They occupy all six zoogeographical regions of the world, and in each region different species have evolved to utilise a massive diversity of ecological niches. This ranges from commensal species such as the Western House Mouse (*Mus domesticus*) to tropical arboreal species such as Prevost's Squirrel (*Callosciurus prevosti*). In behaviour the rodents are again incredibly diverse and species exist that can provide examples of many different strategies across a wide range of habitats. Rodents show a wide variety of foraging specialisations, since by developing such specialist foraging behaviours each species fully exploits its habitat and reduces competition with other inhabitants of the same area. However, within a large number of zoological collections the diversity of rodents is poorly known and even more poorly displayed. Despite the large variety in natural diets and foraging ecology amongst rodents, most species are still fed in captivity with exactly the same diet and food presentation techniques irrespective of their wild ecology. For the majority of rodents this consists of a seed mixture fed in a static food bowl. Rodents have the potential to be more effectively displayed if their natural foraging behaviours are utilised, as well as enhancing the welfare of the individuals themselves through providing environmental enrichment. An example of this is the Fat-tailed Duprasi (*Pachyuromys duprasi*). In the wild this animal is a voracious hunter, and given a regular supply of live insects and molluscs can display active hunting behaviour. Zoos must therefore look to what happens in the wild in order to enhance their displays and improve welfare - and rodents should not be exempt from this rule.*

Keywords

Rodentia, foraging, niches, feeding, captivity, evolution, zoogeography

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The structure of digestive systems in the feeding of mammals: a comparative approach

Abstract

Phylogenetic development and structural adaptations determine optimal utilization of species-specific feeds, and set feeding intervals. This basic rule is frequently ignored in zoo nutrition. Economy-based compromises must embrace natural conditions again and take into consideration complex processes of adaptation to plant defense systems and seasonal adaptations/restructuring of the digestive tract. The relatively simply structured and short carnivore system is robust in comparison with herbivore systems. Hindgut fermentation systems show great phylogenetic diversity (rodents, lagomorphs, hyraxes, perissodactyls, proboscids etc.) but less adaptive plasticity than foregut fermenters (kangaroos, camelids, tragulids, ruminants). In zoo nutrition the complex system of salivary glands is underrated and poorly understood, and appear to utilize their multiple function cascades in species browsing on chemically protected ('antinutritive') plants, not, however, on prefabricated feeds. Similarly, the evolutionary differentiation and co-evolution of ruminants and their main forage plants, as expressed in morpho-physiological variations of several portions of their digestive system, is apparently evened out by standardized feeds with negative long-term results. The importance of selectivity, seasonal adaptations and the limited capabilities to digest cellulose for most smaller herbivores (> 3 kg, < 100 kg body mass) is emphasized. Metabolic adjustments to photoperiodically induced availability and digestibility of forage plants, regression and atrophy of absorptive structures, cyclic restructuring and hypertrophic response to abundance of freely chosen (selected) nutrients can hardly be simulated under zoo regimes. They must be taken into consideration however, in order to prevent long term maladaptation (especially of selective ruminants), breakdown and irreversible destruction of macro- and microstructures of a digestive system originally 'designed' for alternative physiological options (e.g. bypass of soluble nutrients). The widely observed fallacy of generalizations, ignoring feeding type in favor of body mass only (which, in turn, is transformed into grossly standardized, prefabricated feeds), has been documented frequently to be an unpredictable development, from initially compromising nutritional physiology to finally causing irreversible and fatal pathological processes. There is sufficient structural evidence that zoo nutrition, by necessity artificial, is a troublesome however rewarding biological art, that can also easily be harmful to captive animals and is thus ethically doubtful.

Keywords

seasonal adaptation, feeding type, plant defense, fermentation, salivary glands, co-evolution, selectivity.

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A. Melissen

Variation in energy intake in Eurasian otters (*Lutra lutra*): Effects of lactation and seasonal changes

Abstract

Otters are large consumers, daily food intake can mount up to 15 % bodyweight in wintertime, or up to 28 % bodyweight during lactation. In order to investigate variation in energy intake related to changing seasons and lactation, the food intake of 4 Eurasian otters kept at the Otterpark AQUALUTRA was monitored over a period of one year (including a hot summer and a severe winter) and of six months respectively. As Eurasian otters are kept in many countries in Europe, with very different climatic circumstances during the year, data on average temperature during the test period were collected, in order to be able to give more specific advise on gross energy intake related to average environmental temperature. Suggestions on how to increase the amount of food offered to a lactating female otter are also given.

Keywords

Nutrition, Lutrinae, Diet, Food intake

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S. Wamberg, W.H. Hendriks

Nutrient Intake of 1–4 Week Old Suckling Kittens (*Felis catus*): A Model for Artificial Rearing of Young Felidae

Abstract

This study presents data on the daily milk and nutrient intake of the suckling young cat obtained by the water isotope dilution technique. During postnatal weeks 1–4, the kitten's milk intake remained surprisingly constant while their rate of body growth declined from 13.4 g/d in week 1 to 7.6 g/d in week 4. Published data on the composition of mature cat milk were used to estimate the nutrient intake for normal growth and development based on the kitten's daily intake of metabolizable energy. Multiple regression analysis of the kitten's daily intake of milk energy was shown to be highly dependent on their energy requirements for maintenance (282 kJ/kg^{0.75}D) and for body growth (8.47 kJ/g). The values reported may serve as a useful guide for the artificial rearing of the offspring of small and large Felidae and for the manufacture of high-quality milk replacer.

Keywords

Carnivores, Cats, Felidae, Milk intake, Nutritional requirements

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M.D.A. Ticheler, E.J. Vedder, N.M.E. Venmans, J.G. Bindels,
H.S.A. Heymans, R.J.M. Niesink, H. Van Santen,
B. Verstappen-Dumoulin, G.H. Visser

Growth of captive harbor seal (*Phoca vitulina*) pups in relation to the fat content of the milk

Abstract

The most suitable product for rearing captive harbor seal pups until now is Multi Milk® with a fat content as high as 12 %. Because the fat content of seal milk is extremely high (up to 45 %), a fat supplement to Multi-milk® with a fatty acid composition mimicking seal milk fat has been developed. In this study, performed during the summer of 1998, the growth performance of a control group (n = 25) of captive harbor seal pups obtaining standard Multi-Milk® was compared with that of an experimental group (n = 7) obtaining Multi-Milk® with added fat supplement resulting in a total fat content in the milk of about 22 %. We measured the body mass, axillary girth, lean wet mass and fat mass (with the 2H dilution method). Body mass increase was considerably higher in pups of the experimental group (0.27 ± 0.02 kg/day) than those of the control group (control females: 0.12 ± 0.01 kg/day; control males: 0.13 ± 0.03 kg/day). Growth of axillary girth was also significantly higher in experimental animals (0.74 ± 0.08 cm/day) compared to the control animals (control females: 0.10 ± 0.07 cm/day; and control males: 0.12 ± 0.08 cm/day). The growth improvement of the pups was caused by an increase of the lean wet mass (rate of increase of about 0.24 ± 0.06 kg/day in experimental and 0.13 ± 0.01 kg/day in control females) and not by an increase of the amount of body fat (rate of increase of about 0.04 kg/day both in control and experimental pups). In conclusion, although the use of the fat supplement resulted in a considerable improvement of early growth performance of the pups, we were not yet able to achieve growth rates similar to those observed in free-living animals.

Keywords

harbor seal, pup, body growth, fatty acids, stable isotopes, artificial rearing

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Nutritional management of ungulates in captivity – should we learn from natural seasonality of the vegetation?

Abstract

The aim of ensuring an adequate nutritional basis for feeding wild herbivores in captivity is difficult to realize in many cases, mainly because of insufficient data on the particular needs of the species. The natural diet is usually impossible to offer, especially for selective herbivores and for animal species away from their natural climatic zone. To adapt commercial dietary components designed for domestic livestock may be the only alternative in most cases. However, in temperate climatic zones and those close to the polar regions, seasonal variations in the biomass available for consumption of wild ungulates varies by several orders of magnitude, both in respect to quantity and to quality. This is mainly a result of the seasonality in the vegetation period. As a consequence, wild ungulates in the polar region (but also in temperate zones), are strictly seasonal. Reproductive functions with the highest nutritional demand (late pregnancy and lactation), must be synchronized with the vegetation period. However nutritional strategies are often very different between species. Energy expenditure is greatly reduced in winter in many northern cervids. Energy balance is still negative in winter and body fat reserves may contribute substantially to winter energy expenditure. Voluntary feed intake and the extent to which body reserves are accumulated during the vegetation period are not only a matter of feed quality and quantity offered, but depend on day length and season. Seasonal variations of feed intake remains in captivity, even if animals are not breeding and continuous feed supply is guaranteed throughout the year (Von Hegel 1995; Behrend 1999). As a consequence for practical management, northern cervids in particular may need to be fed below voluntary consumption in autumn to avoid the accumulation of body reserves which are not utilized during winter in captivity. A second possible management strategy may be to use the natural seasonal rhythm. To simulate winter conditions, animals may be fed below maintenance and may thereby reduce excess body reserves accumulated previously.

Keywords

Seasonality, feeding, body reserves

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A.A. Macdonald

Comparative anatomy, physiology and ecology of pregnancy and lactation in wild pigs: a review

Abstract

The nutritional requirements of animals during pregnancy and lactation differ from the requirements of the growing animal, or the non-pregnant adult, as revealed by studies of the domestic species. However, relatively little information has been published to indicate the comparable requirements for pregnancy and lactation of most animals in the wild. Similarly, there is as yet surprisingly little information available from the study of animals in zoological collections. Analyses of the comparative anatomical and physiological data can contribute to our understanding of the problem. Similarly, behavioural and other data may help to indicate some aspects of the relationship between the pregnant or lactating animal and its environment. As with many other widespread groups of animals, the nature of the relationships which exist between various Eurasian, African and Southeast Asian wild pig species and their respective environments during pregnancy and lactation has not attracted specific research attention. This review first seeks to gather together what is available, and on the basis of an analysis of this, to establish an investigative framework within which future studies may be undertaken. The anatomical and physiological changes which occur in different parts of the sow during pregnancy and lactation are described for the different species of pig, and the related changes in the behaviour and feeding patterns of the piglets and the sow are reviewed.

Keywords

body weight

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Feeding babirusa (*Babirusa babirusa*) in captivity

Abstract

*This paper reviews the available information on stomach anatomy, digestion, foraging behavior and diet of wild and captive babirusa. Based on this information, suggestions for changes in the diet of captive babirusa are formulated, which will then need to be assessed. Published information suggests that wild babirusa show a marked preference for fruit supplemented with leaves, herbaceous material and a fair amount of animal material as well as mineral-rich soil and water. Behavioral observations on wild and captive babirusa indicated that they usually practice surface foraging, that rooting only takes place in loose soil, that they stand on their hind legs to reach food in higher places and that males tend to monopolize food when animals are fed together. Although unilocular, the babirusa stomach contains an enlarged area of mucus-producing cardiac glands (> 70 % of internal surface area v. 30 % in *Sus scrofa*) with a pH between 5.3 and 6.4 and populations of microorganisms. The true gastric glands are confined to a small gastric unit. Results from two independent digestibility studies on captive babirusa were in concordance with the general characteristics of non-ruminant forestomach fermenting frugivore/concentrate selectors. Passage time experiments suggested that no part of the digestive tract selectively held digesta longer than any other part and that caecocolonic fermentation may be less important in the babirusa than in the Eurasian wild pig. Analyses of the diets offered to babirusa in zoos worldwide revealed a very wide spread in nutritional values. The zoo diets were low in fiber and most zoos fed excess protein and energy. Browse was offered in a non-systematic way. Using the above information and adapted prediction equations suggestions for changes in the diet of captive babirusa were formulated, which will then need to be assessed.*

Keywords

diet, digestion, nutrition, fermentation, pig

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E. Wagner, J. Boehm, H.A. Abdel-Raheem

Effects of the dietary calcium and phosphorus levels on the metabolic balance of some microand some macro elements in one-humped camels (*Camelus dromedarius*)

Abstract

This study was designed to study the effects of dietary Ca and P on the metabolic balance of micro and macro elements in camels. Rations containing 0.56 % Ca and 0.34 % P are considered to fit well for nonlactating adult camels. Over- and undersupplementation of Ca and/or P disturbed the metabolic balance of macro and micro elements, e.g. high Ca and normal P intake led to decreased apparent absorption of those elements and Mg, whereas no changes were observed in Na and K absorption. All changes in dietary Ca and P altered the absorption of Mn. Increasing dietary Ca decreased slightly the absorption of Zn and Cu. Serum levels of elements were not changed within the trials.

Keywords

Camelidae, mineral content, metabolic balance of micro- and macroelements, mineral supplements, bioavailability

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*S. Crissey, E.S. Dierenfeld, J. Kanselaar,
K. Leus, J. Nijboer*

Feeding guidelines proposal for okapis – a joint European and North American project

Abstract

*During the Okapi Metapopulation Workshop (Dierenfeld, 1996) it was decided that more information was needed describing captive okapi (*Okapia johnstoni*) diets. Recommendations for providing appropriate diets to captive okapis also were to be developed. With these objectives in mind, the North American and European okapi nutrition advisors collected information on and compared okapi diets fed in North American and European zoos. The data also were compared with available data from studies of captive okapi offered natural food items in the Democratic Republic of Congo (formerly Zaire). Based on these findings and other information described in this paper, recommendations for feeding okapis are being provided to the SSP/EEP okapi groups for review and discussion.*

Keywords

*Herbivore, okapi, *Okapia johnstoni*, nutrition, captive feeding, analyses*

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M. Clauss, E.J. Flach, K. Ghebremeskel,
C. Tack, J.-M. Hatt

Supplementing the diet of captive giraffe (*Giraffa camelopardalis*) with linseed extraction chips

Abstract

Captive giraffe (*Giraffa camelopardalis*) are reported to have low linolenic acid concentrations in body tissues in comparison with free-ranging individuals. However, it is not known whether this merely reflects a different diet, or whether it impairs body functions. As linseed contains significant amounts of linolenic acid, the feeding of linseed extraction chips might be a practical way of supplementation. Captive giraffe with low linolenic acid status in their blood lipids (compared to domestic ruminants) were introduced to a diet that included linseed extraction chips. Blood lipids of animals from which samples were available after the change in dietary regime ($n = 2$) showed an increase in linolenic acid content. One of the animals had a history of skin lesions resistant to treatment. The skin lesions improved markedly during the course of linseed supplementation. While long-term effects of either linolenic acid deficiency or linolenic acid supplementation in giraffe remain to be demonstrated, these results suggest that giraffe might benefit from the addition of linseed extraction chips to their diet.

Keywords

polyunsaturated fatty acids, linolenic acid, skin lesion, peracute mortality syndrome

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Copper and Manganese Status in Ruminants

Abstract

The copper (Cu) and manganese (Mn) status of different ruminants depends on the species, and the dietary intake and thus organ tissues of different wild ruminant species were analyzed and compared with domestic ruminants. The Cu concentrations in the liver and cerebrum indicating sufficient Cu status are lower in some species of wild ruminants kept in captivity, wild living deer, and domestic goats than in cattle and sheep (35 mg Cu/ kg liver dry matter (dm), and 9 mg Cu/ kg cerebrum dm). A lower limit value is assumed for blackbuck, Cuvier's gazelle, Roosevelt's gazelle, duiker, sable antelope, kudu, aoudad, and sika. Apart from gazelles and duikers, the Mn concentration in the liver of most of the ruminant species does not reach the limit value for a sufficient Mn supply (8 mg Cu/ kg liver dm) valid for cattle and sheep. Contrary to that, the Mn content of hair was lower in deer and duikers compared to other ruminant species.

Keywords

Minerals, nutrition, ruminant

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Iron in the Liver of Animals in the Zoo: A Pathologists point of view

Abstract

Based on a retrospective study the iron content of the liver was evaluated in histological slides stained with Prussian blue. The amount was scored semi-quantitatively in the hepatocytes and Kupffer cells. The livers of 945 birds (13 orders), 179 New World monkeys (11 families), and 137 Artiodactyla (6 families, 32 genera) were evaluated. The results indicate different sensitivity to iron storage in different species or groups of animals. There was a remarkable difference in iron load in some species between two larger zoos, indicating differences in dietary iron content. In many species iron was restricted to the reticulo-endothelial-system, which might be related to specific iron absorption-capacity of macrophages. In the discussion these findings are correlated with the most recent opinions about iron metabolism, hemosiderosis and hemochromatosis.

Keywords

Iron, liver, intestinal epithelial cell, hemosiderosis, hemochromatosis, mucosal block ferritin

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Regulation of food intake in monogastric and ruminant animals

Abstract

Adult individuals are usually characterized by a balance between energy intake and energy expenditure. Food intake is controlled by various feed back systems with their signals being integrated in the central nervous system (CNS). Short-term regulation of food intake mainly involves feed back signals from the gastro-intestinal tract. They may be positive (e.g. from the oral cavity) or negative in nature. Distension of the stomach (or forestomachs) leads to the activation of vagal afferents projecting to the nucleus of the solitary tract in the hindbrain being connected with the hypothalamus. The presence of nutrients in the small intestine (or rumen) is sensed and the information transmitted via vagal afferents. Other important feed back signals are various hormones such as cholecystokinin (CCK), gastrin-releasing peptide and the pancreatic peptides amylin, glucagon and insulin. These satiety hormones act partly via receptors on afferent nerves (CCK) or directly in the CNS (amylin, insulin). Feed back signals from the hepatoportal area are postabsorptive in nature. The availability of glucose (propionate in ruminants), the oxidation of fatty acids and the energy status in general appear to be sensed in the hepatoportal area with the signals being transmitted mainly via hepatic vagal afferents. The lipostatic theory of the long term regulation of food intake and body weight postulates the presence of humoral factors whose concentration depends on the size of the adipose tissue. Leptin and insulin are such factors, and both constitute negative feed back signals acting directly on the brain. Their main target organ is the hypothalamus, the main integrating center for the control of food intake. Within the CNS, numerous neurotransmitters interact in a complex system to control food intake.

Keywords

short-term regulation, long-term regulation, satiety hormones, central nervous system, hepato-portal area, Lipostatic theory, Leptin, disease, seasonal mammals

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Vitamin C Nutrition in Zoo Animals

Abstract

Nutritional deficiencies related to vitamin C are occasionally reported in zoo animals. The problem can occur in animals with an essential requirement for ascorbic acid, i.e. primates, guinea pigs, certain bat species, some passeriform birds, most fish and crustaceans, invertebrates, and insects. Other animals that have the ability to biosynthesise vitamin C can also develop marginal deficiencies due to stress or diseases. To overcome such nutritionally deficient episodes it is common practice to supplement the feed with vitamin C. The product forms of vitamin C which are available on the market are reviewed. To elucidate the stability of vitamin C, a coated form and a phosphorylated form were tested in mash and pelleted guinea pig feed. All feeds were exposed to either room temperature (20–24 °C) or 35 °C. A sample of pelleted feed was also irradiated and stored at room temperature. Vitamin C activity was analysed before and after pelleting process, and after 1, 4 and 7 months. In mash feed the coated vitamin C showed sufficiently good stability over the seven month storage period. In the pelleted feeds, including the irradiated feed, only the ascorbyl-phosphate form showed high retention figures for vitamin C during the entire storage period.

Keywords

ascorbic acid, ascorbyl-ester, essentiality, stability, guinea pig

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