13.7 Guideline - Dietary management of lemurs in captivity

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1. Purpose

1.1 Zoo and Aquarium Association institutions in Australasia currently hold two species of lemur:
   (a) ring-tailed lemur (*Lemur catta*)
   (b) black and white ruffed lemur (*Varecia variegata*)

1.2 These guidelines summarise information on commonly encountered health issues in captive lemurs. They are intended to provide information and recommendations to Association member institutions holding lemur species.

1.3 These guidelines are to be read in conjunction with the following policies, procedures and guidelines of the Association:
   13.6 Guideline - Veterinary and health management of lemurs in captivity.
2. **Definitions**

In these guidelines, unless the context requires otherwise: **Board** means the board of management of the Association. **Executive Director** means the Executive Director of the Association. **Member** means a member of the Association, as defined in the Association’s Membership Policy, and may include an employee, officer or agent of a Member of the Association. **Organisation** means an unincorporated entity, or an entity incorporated under commonwealth, state or territory legislation. **Association** means the Zoo and Aquarium Association Inc. (ABN 71 836 556 156).

3. **Summary of recommendations**

Specific dietary requirements have not been determined for most lemur species. In the wild ruffed lemurs are more frugivorous than ring-tailed lemurs but in captivity care needs to be taken to avoid overfeeding, especially highly digestible fruits, and to ensure that sufficient fibre is provided. To prevent dietary health issues, feed rations need to be carefully formulated and nutritional analysis is recommended.

In order to adequately meet but not exceed estimated nutrient requirements, captive lemurs should be fed a diet based on a commercial primate kibble or pellet with an appropriate fibre content, supplemented with a variety of fresh vegetables, browse, restricted quantities of fruit and limited amounts of high fat/high protein enrichment items.

These guidelines should be read and utilised by animal managers and animal health staff at all Association organisations holding lemurs.

4. **Background**

The development of dietary guidelines for this taxon has been inspired by concerns regarding the incidence of diseases with a known or suspected dietary cause and the desire to provide optimal nutrition to promote physical, behavioural and reproductive health. There is evidence that, at least in zoos in North America, the diets of lemurs in zoos vary widely between institutions and may not reflect diets in the wild.

Although exact nutritional needs of lemurs have not been elucidated, there are some basic principles that should be incorporated into the formulation of diets, based on an understanding of natural feeding ecology, established or suspected nutrition-related health concerns in captivity, historical diets and a review of the literature.
This document aims to briefly summarise the current understanding of captive lemur nutrition and to provide some broad dietary guidelines for institutions holding or planning to hold lemurs in the region.

5. **Principles of captive wildlife nutrition**
   - Diets should be formulated in conjunction with, or under the guidance of, a professional with expertise and experience in managed feeding programs and/or nutrition of captive primates e.g. a veterinarian and/or nutritionist.
   - Captive diets should meet but not greatly exceed known or estimated nutritional requirements.
   - Captive diets should be palatable, practical and economical to feed.
   - Captive diets should reasonably stimulate natural feeding behaviours.
   - Foods used for enrichment, training programs, and/or treats should be included in calculations when balancing the total diet.
   - Feeding behaviours should be monitored and documented.

6. **Lemur feeding ecology**
   Unlike other primate groups, prosimians are capable of producing their own vitamin C and do not require a dietary source of this vitamin\(^4\). They have a low basal metabolic rate so their daily intake requirements are commonly overestimated in captivity.

6.1 **Ring-tailed lemur**
   The ring-tailed lemur is considered to be mainly frugivorous/folivorous, consuming a wide variety of plants, although there is significant variation in dietary items depending on seasonal availability and habitat. They have been observed feeding on ripe and unripe fruit, leaves and flowers as well as sap, invertebrates, soil and dead wood. The hind gut has the capacity for fermentation of moderate fibre levels\(^5\).

6.2 **Black and white ruffed lemur**
   The black-and-white ruffed lemur is the most frugivorous of the lemur family with fruits making up 92% of the total diet during feeding observations of wild animals\(^6\). They have a simple hindgut with a rapid passage rate which limits their fibre fermentation capabilities\(^7\) compared to other lemur species. As a result ruffed lemurs are more dependent on fat and non-structural carbohydrates (sugar and starch) than on fibre fermentation for energy. It is important to recognise that the nutritional composition of wild fruits differs considerably from cultivated fruits for human consumption; with wild fruits being higher in fat and fibre and lower in crude protein, sugar and starch\(^8\) than the foods typically used in zoo-based diets.
7. **Nutrition-related health concerns in captive lemurs**

Obesity is a major nutritional problem in captive lemurs which results from excessive calorie intake and lack of exercise/sedentary lifestyle \(^9,10\) and may have an adverse effect on the ability to successfully reproduce in captivity.

*Diabetes mellitus* has been reported in several lemur species. In ring-tailed lemurs obesity has been shown to be a contributing factor to the development of this disease \(^11\).

**Iron storage** (encompassing both haemosiderosis and haemochromatosis) has received a lot of attention in the literature pertaining to lemur nutrition but the condition’s health implications and precise relationship to diet are still unclear. The term haemosiderosis describes iron deposition in tissues without associated pathology and is often an incidental finding on post-mortem examination. Haemochromatosis, on the other hand, refers to iron deposition in tissues that is associated with pathology and disease. Several, but not all, surveys of lemur pathology indicate a predisposition to iron storage in some lemur species with ruffed lemurs apparently more susceptible than ring-tailed lemurs \(^12\). With improvements in captive management overseas, recent work suggests that although haemosiderosis remains commonplace, haemochromatosis is rarely seen \(^13\). Iron may be deposited in tissues throughout the body as a result of both nutritional and non-nutritional (e.g. genetic) factors and the interplay of iron with other nutrients such as copper, manganese, zinc, vitamin C and calcium may be important \(^4,14\). As iron storage in the body is a cumulative process with the deposits building up over the course of a lifetime, taking steps to prevent disease through good dietary practices from an early age is considered prudent \(^12\). The ability to accurately assess the iron status of collection lemurs in Australasia is currently limited by a restricted panel of available laboratory assays.

**Insufficient fibre levels** can result in diarrhoea, poor blood sugar regulation (leading to diabetes), poor weight management and reduced satiety. Although black-and-white ruffed lemurs have a limited capacity for fibre fermentation with 80% of the plant cell wall being lost in faecal material, indigestible fibre has been shown to have other positive health benefits\(^7\). The highest fibre diets fed in captivity do not reach the levels detected in wild dietary items and it is noteworthy that feeding adequate fibre is associated with a reduced risk of iron storage disease. Recommended minimum fibre levels are 20% neutral detergent fibre and 10% acid detergent fibre (ADF) although it seems that higher levels (> 15% ADF) may be preferable.

8. **Wild diets versus captive diets**

A recent survey of black-and-white ruffed lemur diets in captivity in North America revealed that zoo-based diets contained higher protein and lower fibre and fat concentrations than wild diets\(^2\). The markedly lower fat and fibre content is thought to reflect the chemical
composition of domestic fruits that are often fed in excess of requirements. Wild fruits eaten by lemurs have nutritional characteristics more similar to commercially produced vegetables, than the fruits marketed for human consumption. There has been no region-wide study in Australasia examining the macronutrient content of captive lemur diets but there is anecdotal evidence that fruit comprises a significant component of many diets.

Diets of free-ranging lemurs are lower in dietary iron and higher in substances that reduce iron availability (phenols such as tannins) than captive diets. It has been shown that the levels of tannins in the wild diet vary seasonally and that there are species differences in tannin level tolerance.

9. **Dietary recommendations**

- The exact composition of lemur diets will vary from one institution to another, depending on local availability of feed items, individual animal preferences, other species held and feed budgets.
- Diets should be formulated to meet minimum guidelines for non-human primates published by the National Research Council with some consideration of species specific differences.
- As a guide a dry matter intake of 2-2.5% of body weight is recommended. Feed volumes should be adjusted as required based on regular assessment of body condition.
- The diet should be presented in such a way as to promote foraging activity and manipulation for weight management and behavioural enrichment: this can be done by varying the daily presentation of supplementary feed items, utilising different feed locations and the use of scatter feeding.
- Dietary components:
  - **Commercial primate pellets/kibble**
    Offering a commercial balanced pellet or kibble designed for non-human primates is considered to be the most appropriate way to ensure macro- and micronutrient requirements are met, and not exceeded. In Australasia there are limited products that are commercially manufactured for this purpose. It may be necessary to have a feed mill specially formulate a pellet to the required composition. If a homemade pellet/cake is used instead, it is strongly recommended that batches of the product are analysed regularly for macro- and micronutrient content because ensuring the correct balance of nutrients is challenging by this method. Ring-tailed lemurs can tolerate relatively high fibre pellets, but pellets as high as 30% acid detergent fibre may result in weight loss in black-and-white ruffed lemurs.
  - **Fresh produce**
    The bulk of the remainder of the diet is usually comprised of a variety of vegetables and fruits. To avoid excessive vitamin C intake citrus fruits should only be used in moderation, if at all. For weight management avoid excessive amounts of all fruits...
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due to the high non-structural carbohydrate level and low fat and low protein levels. A mixture of leafy green and starchy vegetables is also recommended.

- **Other items**
  Small amounts of cooked or unsweetened canned beans, vegetable oil or nuts can be used to increase protein or fat levels and to improve palatability.

- **Browse**
  Locally available fresh leaves and browse can be useful to increase dietary fibre and to stimulate natural feeding behaviours. It is recommended that collections consult the ZAA Browse Database 17 (updated in 2013 by the Horticulture SAG) to select plants that have been used without incident in other institutions holding non-human primates. Avoid plants known to be toxic to other animals or humans, and do not collect browse that may be contaminated with pesticides or other chemicals. Ruffed lemurs may have a limited ability to digest highly fibrous browse items but there is evidence that their inclusion in the diet has benefits for gastrointestinal health and behaviour.

- **Supplements**
  Vitamin and mineral supplements are only necessary if the consumed diet is shown to be deficient in one or more nutrients. Generally supplement products with high levels of vitamin C or iron should be avoided.

- At the present time there is insufficient evidence that the addition of tannins to the diet is beneficial. These compounds do decrease iron absorption but they can also alter the availability of other key nutrients and therefore have the potential to contribute to deficiencies. Feeding a well-balanced species-appropriate diet with adequate fibre levels will likely minimise excessive iron absorption 4.

10. **Future studies**

A review of regional dietary trends for captive lemurs in Australasia has not been undertaken but would have some merit in further refining these recommendations. To facilitate future studies it is essential that all collections holding lemurs keep detailed dietary records, including items offered, amounts/types of foods eaten, nutrition-related disease concerns and to document any changes that are made.

11. **Summary**

Specific dietary requirements have not been determined for most lemur species. In the absence of more detailed studies, lemurs should be maintained in captivity on a diet based on a commercial primate kibble with an appropriate fibre content for the species, supplemented with a variety of fresh vegetables, fruit (restricting citrus), browse and limited amounts of high fat/high protein enrichment items. The diet should be analysed to ensure minimum requirements of macro- and micronutrients are met. If vitamin or mineral supplementation is considered necessary, the use of products with high levels of vitamin C
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or iron should be avoided. To reduce the risk of obesity, care needs to be taken to avoid overfeeding, especially highly digestible fruits. Ruffed lemurs are more frugivorous than ring-tailed lemurs and they have limited capacity for fibre fermentation. However the fruits they select in the wild differ vastly in chemical composition from human-grade cultivated produce. Adequate fibre levels are important for all species for weight management, gastrointestinal health and prevention of diabetes and may reduce the tendency to store iron in their tissues.

12. References


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13. Approval

These guidelines were approved by the Executive Director of the Association on 22/01/2016.

**Revision Record**

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