

## **Fruit Bat Husbandry Manual**

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### **V. Nutrition**

Development of the nutrition chapter has proven to be very complex and poses many challenges. For every institution that houses bats, there are almost as many different diets utilized. The purpose of this chapter is to provide general guidelines for managers to consider when developing a diet for bats. Here we present target nutrient ranges and practical diets that meet these ranges. The Bat TAG Nutrition Subcommittee is continuing to research this important topic, and this chapter will be updated on a regular basis as new information becomes available.

Meeting the nutritional needs of Megachiropteran and Microchiropteran fruit bats is essential if they are to thrive in captivity. Developing appropriate dietary guidelines is an extensive project that involves utilizing information from a number of sources. These sources include current feeding ecology data, published nutrient requirement data, food available to zoos, and food preferences of fruit bats, as well as input from academia and data on the nutrient content of successful diets currently in use.

#### **V.A. Foraging Ecology**

Currently, it appears that the majority of data about foraging ecology is a description of the bats' feeding or foraging habits in the wild. Some studies have involved collecting and analyzing food items for various nutrients (Morrison, 1978; Morrison, 1980; Thomas, 1984). Others examined excreta or stomach contents of bats in the wild (Stellar, 1986; Thomas, 1984). Each of these methods has its limitation and none quantitatively defines the daily nutrient requirements of fruit bats. Thus to date, there is little information available that describes the nutrient levels required by fruit bats. The only fruit bats for which estimates of nutrient requirements have been made are in the suborder Megachiroptera (Stellar, 1986; Thomas, 1984). Few, if any, quantitative nutrient requirement data for frugivorous Microchiroptera are available.

Many species regularly consume fresh green forages; however, the extent to which forages contribute to overall nutrition is unknown (Kunz and Ingalls, 1994; Kunz and Diaz, 1994; Marshall, 1985). Additionally, fruit bats consume other plant parts including flowers, nectar and pollen (Bradley-Law, Lowry, Marshall, 1983).

#### **V.B. Nutritional Requirements**

The nutrient requirements of Megachiropteran and Microchiropteran fruit bats remain unknown, although studies have been conducted on the protein and energy requirements for certain species of fruit bats (Delrome, pers. comm., Kunz and Diaz, 1986; Thomas, 19984). To establish target nutrient levels, we will be using the previously mentioned data, new research data and data gathered from successful diets currently used.

Despite consumption differences among species of mammals, it is likely that bats, like other mammals, have similar qualitative nutrient requirements for tissue metabolism. Although few studies have been conducted to establish nutrient requirements, the National Research Council has described the nutrient requirements of a number of domestic and laboratory animals. Using the NRC guidelines along with data on feeding ecology and nutrient content of successful diets currently in use will allow us to formulate appropriate diets for frugivorous captive Chiroptera. This appears valid at this time considering no extensive data exist specifically for bats.

Preliminary data for meeting target nutrient levels are presented below. These values are for reference only, as all data needed to make firm recommendations are not compiled.

### **Preliminary Target Nutrient Levels (dry matter basis)**

Nutrient	Daily Diet Composition
Crude Protein (%)	2.0 – 15.0 *
Fat (%)	5.0 – 9.0
Vitamin A (IU/g)	4.0 – 14.0
Vitamin D <sub>2</sub> & D <sub>3</sub> (IU/g)	0.2 – 2.0
Vitamin E (mg/kg)	11.0 – 56.0
Calcium (%) **	0.5 – 1.0
Phosphorus (%) **	0.4 – 0.9

\* Reported levels of protein consumed by free-ranging and captive Megachiropteran and Microchiropteran fruit- and nectar-feeding bats fall in this range (Morrison, 1980; Rasweiler, 1997; Reiter, 1993; Stellar, 1986; Thomas, 1984).

\*\* For Mammals, Calcium:Phosphorus ratios of 1.1 to 2.1 are recommended (Robbins, 1993).

### **V.C. Nutrient Content of Three Working Diets**

Because we have yet to delineate the target nutrient levels, we are providing diets that, on face value, appear to meet the above indicated nutrient levels. No examination of micro-nutrient levels has occurred. These diets have been reported by several institutions that consider their programs successful. Please note that there are presented only as suggestions and have not been subjected to thorough review. To provide suggestions for easily adaptable diets, the data have been modified slightly and presented as food groups rather than specific food items. The total quantity to feed is not given and is dependent on many factors. However, as a rough guideline, an average active adult bat may consume a total of approximately 10 – 15% of body weight per day (dry matter basis); or 50 – 120% of body weight on an as fed basis. If the animal is lactating this may increase to 1.5 times that per day. Care should be taken that the animals do not become obese when fed *ad libitum*.

### **Comparison of the Approximate Nutrient Content of Three Working Diets with Preliminary Target Nutrient Levels (dry matter basis).**

Nutrient	Target Levels	Zoo A	Zoo B	Zoo C *
Crude Protein (%)	2.0 – 15.0	12.3	19.0	4.9
Fat (%)	1.0 – 5.0	7.2	3.0	4.4
Vitamin A (IU/g)	4.0 – 14.0	26.0	14.9	8.1
Vitamin D <sub>2</sub> & D <sub>3</sub> (IU/g)	0.2 – 2.0	6.2	3.2	0.1 **
Vitamin E (mg/kg)	11.0 – 56.0	133.1	50.2	29.8
Calcium (%)	0.5 – 1.0	0.4	0.8	0.1 ***

Phosphorus (%)	0.4 – 0.9	0.3	0.4	0.1
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\* Values reported are averages because daily diet composition varies at this Zoo

\*\* Animals at this facility are housed under full spectrum lights

\*\*\* Animals have *ad libitum* access to a mineral wheel

### V.D. Working Diet Composition

We are aware of a number of nutritional concerns about some of the diets being used in captive feeding regimes today. We hope to address these in the final document.

**Food Items:** The proportions represented below are derived from the three working diets presented above. It is possible to achieve the nutrient levels of the Zoo diets outlined above by offering a diet consisting of the following food items. For adaptability to different institutional situations, we are presenting the diets as food groups in percent to be included in the total diet. This is percent contribution of each item (or food group) by weight, as fed.

### Comparison of the Percent Contribution of Food Groups in Three Working Diets (as fed basis).

Food Group	Zoo A	Zoo B	Zoo C *
Fruit (%)	74.1	16.0	90.4
Vegetables (%)	-	7.0	-
Starchy vegetables (%)	-	7.0	-
Leafy, green vegetables (%)	-	14.0	2.3
Fruit juice/nectar (%)	-	-	6.5
Water (%)	-	41.0	-
Nutritionally complete products (%)	23.3 **	7.5 ***	-
Protein supplements (animal-based) (%)	-	-	0.7
Home-made protein/vitamin/mineral supplements (%)	2.6	7.5	0.1

\* Values reported are averages because daily diet composition varies at this Zoo.

\*\* This consists of 14.2% canned primate diet and 9.1% canned feline diet.

\*\*\* Total contribution is from high protein monkey chow.

**Food Groups:** The diet can comprise one or more of the following in the quantities outlined above.

Fruit: apple, banana, grapes, pear, papaya, dried figs, raisins, melon, kiwi, etc.

Vegetables: carrots, green beans, etc.

Starchy vegetables: sweet potatoes, corn, etc.

Leafy, green vegetables: lettuce, spinach, kale, collard, mustard, etc.

Please notice that all of the working diets outlined above use home-made supplements in conjunction with commercially-made, nutritionally complete products. If one or more of the products are not included in each of the diets as outlined, the diet will no longer reflect the nutrients presented in the previous section. Many of the home-made recipes are difficult, and sometimes expensive to make. Therefore, in the final nutrition chapter we intend to provide recommendations for use of easily attainable, nutritionally complete diets that will allow formulated diets to meet target nutrient levels.

### **V.E. Information Needed**

There remains a large amount of information to be collected in order to finalize recommendations for target nutrient levels and appropriate feeding procedures for Megachiropteran and Microchiropteran fruit bats. Much of this information will become available through our proposed pre-survey and following in-depth survey of diets and feeding practices in institutions currently housing fruit bats. The information still needed includes, but is certainly not limited to the following: Nutritional deficiencies/toxicities, feeding behavior in captivity, quantities of food to offer (factors include: age, species, size of housing, number in group, etc.), form of diet offered (e.g., chopped vs. whole fruits, etc.), problems with obesity, seasonality (e.g. feeding different diets based on season), feeding schedules, feeding location, use and potential nutrient contribution of fresh green forages and other plant parts, behavioral enrichment for captive fruit bats.