MAMMAL NUTRITION — HOW COOKBOOKS CAN BE HARMFUL*

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INTRODUCTION

Providing the proper nutrition to wildlife in a rehabilitation setting is a crucial element to an animal's ultimate recovery and/or growth and development leading to a successful release. Unfortunately, selection of the right substitute milk formula for infant and juvenile mammals can be a daunting task for both novice and veteran wildlife rehabilitators.

Selection of proper diets is a complex subject with many variables that may at times involve using mathematical equations to calculate nutritional components and energy values contained in a formula. Rehabilitators attempting to achieve the best nutrition for the wild animals in their care find this task challenging. Wildlife rehabilitators should seek out a basic understanding of nutrition from a variety of sources, including professional animal nutritionists and the published literature that deals with animal husbandry and diets (Pond et al. 1995; Cheeke 1999; Perry et al. 1999).

BEWARE OF COOKBOOKS

Unfortunately, because of the complexity involved, many rehabilitators have simply turned to some of the existing popular wildlife rehabilitation literature that provides "cookbook" suggestions as to which milk replacer products to use with certain species, even recommending very specific formulas (Marcum 1997a, 1997b; PetAg 1993). Manufacturers of some of the milk replacer products offer specific mixing instructions for their products for use with certain species, as

well as frequency and amount of feeding (PetAg 1993). Since many factors influence the relative success of one formula over another, these cookbook recommendations should be viewed only as a starting point when determining the best formula to use for a specific species. Some of the data in the published literature has proven to be based on incorrect nutritional values for various commercial products, or the commercial formulas may change over time (Marcum 1997a, 1997b; PetAg 1993). Simply following some of these basic — and at times incorrect — suggestions in some of this literature can prove harmful to a wild animal's health and development.

MATCHING MOTHER'S MILK

The goal of published substitute formula recommendations is to closely match the nutritional components and energy content of the mother's milk of a particular species, as determined by field and laboratory studies. Unfortunately, these studies are limited in number (Marcum 1997a). While theoretically appealing, this mathematical approach fails to consider many of the key principles involved in understanding mammal nutrition (Church et al. 1995). The composition of the mother's milk of many wild mammals has been examined by only one to at most a few studies. The differences in study values for a single species for which more than one study was conducted range more than 100 percent for certain nutrients and over 50 percent for energy content. The same level of error or uncertainty may likely be present in reported values for a species where only one study is available. Because of this wide range of uncertainty, reported values from studies (some performed 20 to 40 years ago) are best viewed as an approximation of the actual nutritional content of the milk of wild lactating females.

The digestibility of a substitute milk formula should be considered when attempting to match a wild mammal's milk. Digestibility, the percentage of a foodstuff taken into the digestive tract that is absorbed into the body, involves preparation of food for absorption (true digestibility) and subsequent absorption in the gastrointestinal (GI) tract. Matching the nutritional and energetic contents of diets does not take into account the marked differences of various species regarding their ability to digest certain foods. Digestibility is variable and determined by factors such as level of food intake, digestive disturbances, nutrient deficiencies, ingredients, and feeding frequency. Even if a diet is digested, nutrient utilization can be affected by factors including species, age, feeding amount and frequency, disease, parasites, and

level of stress. Unfortunately, many cookbook suggestions in the literature fail to recognize or incorporate these factors or find it difficult to address them. Knowledge of the nutrition of wild mammals and/or the advice of someone familiar with the nutrition of young wild mammals are essential.

MATHEMATICAL ERRORS

Mathematical equations can be used to precisely calculate the energy and nutritional components of a formula (Figures 1 and 2). However, error can be introduced at different points during the calculations. Use of either an incorrect or less-precise nutritional analysis can cause errors in the calculation of the nutritional composition of a formula. Many of the commercially available milk replacer products provide an approximate analysis, or guaranteed or proximate analysis, on the product label. This labeling is usually required by law and provides component guarantees for minimum protein and fat and maximum carbohydrates, crude fiber, ash, and moisture. While the percentage values provided are directionally correct, they do not provide the degree of accuracy needed to calculate more precise nutritional components of a substitute milk formula.

The manufacturer of a milk replacer can usually provide a much more detailed and accurate chemical analysis of the product upon request. This description of the product is referred to as a "typical nutritional analysis" and provides a detailed listing of the components of the product. This listing (Table 1) often provides details for protein, amino acids, fat, cholesterol, fatty acids, fiber, starch and sugars, minerals, vitamins, ash, and gross and metabolizable energy. Generally, this is the preferred data set to use when calculating nutritional and energy values for mammal formulas.

Error can be introduced in the way the manufacturer arrives at a value for metabolizable energy (ME) for a product, usually expressed in kcal per gram. The most precise way to calculate ME is to take the gross energy (GE) of the food fed, minus products of elimination (feces, urine, and gaseous products of digestion, mostly methane). Gross energy is the energy value from complete oxidation of the food. This is a very complex and time-consuming measurement and will vary among species for the same food product. Some manufacturers simply estimate ME using factors for protein, fat, and carbohydrates contained in the product, but generally indicate this can vary up to ± 5 percent. To the extent a formula is mixed from multiple products, this degree of error is multiplicative.

$$\frac{(P_{X1} \cdot DW_{X1} \cdot ME_{X1}) + (P_{X2} \cdot DW_{X2} \cdot ME_{X2}) + \cdots + (P_{XN} \cdot DW_{XN} \cdot ME_{XN})}{TW} = \frac{\text{kcal}}{\text{gram}} \approx \frac{\text{kcal}}{\text{cc}^*}$$

P = Parts of a product (can be any unit of measure, such as tablespoon, cup, etc.).

X = Product (where $X1$ = product 1; $X2$ = product 2; XN = last product).

DW = Dry weight of a product per part (grams).

ME = Metabolizable energy value of a product (kcal per gram).

TW = Total weight of all products, plus the weight of the water used in the formula (grams).

* Note: The ME kcal value for a given mixed formula using the above equation yields kcal per gram of weight. Empirical observation indicates that 1 cc of any of the mixed milk replacer formulas weighs very close to 1 gram. Therefore, the above equation produces a result that can be used to roughly approximate the ME kcal value for a cc of mixed formula. A more accurate calculation would involve using an equation that calculates ME kcal per liquid volume (cc) and would require the use of factors that would account for the volume expansion that occurs when dry products are mixed with water. These factors would provide a volume expansion coefficient for each product when mixed, based on the density and solubility of each product. Since these factors are unavailable, the above equation (based on weight) can be used to arrive at ME kcal values for any given formula mix.

Figure 1. Equation used to calculate metabolizable energy (ME) in a mixed liquid formula (Pond et al. 1995).

$$\frac{P_{X1} \cdot DW_{X1}}{TW_Y} \cdot C_{X1} + \frac{P_{X2} \cdot DW_{X2}}{TW_Y} \cdot C_{X2} + \cdots + \frac{P_{XN} \cdot DW_{XN}}{TW_Y} = C_Y$$

P = Parts of a product.

X = Product (where $X1$ = product 1; $X2$ = product 2; XN = last product).

DW = Dry weight of a product per part (grams).

C = Nutritional component of a product (e.g., solids, protein, fat, etc.) as a percent of total product matter.

TW = Total weight of all products, plus the weight of the water used in the formula (grams).

Figure 2. Equation used to calculate the percentage of nutritional component in a mixed liquid formula (Pond et al. 1995).

Table 1. An example of the nutritional analysis provided by PetAg for the milk replacer product Esbilac. All values are percent of the total dry weight of the product.

Guaranteed analysis (%)		Typical nutritional analysis (%)	
Crude protein (minimum)	33	Crude protein	33.61
Crude fat (minimum)	40	Crude fat	42.79
Crude fiber (maximum)	none		
Ash (maximum)	7.75	Ash	7.49
		Lactose	13.69
		Solids	97.58
Moisture (maximum)	5	Moisture	2.42
		Total	100.00

Another source of error can be introduced by the way the rehabilitator measures the dry and wet contents of a formula prior to mixing. The value for metabolizable energy contained in the typical nutritional analysis provided by the manufacturer is based on a precise weight for a given volume of the product. Accurately weighing both the volume of milk replacer product used and the water mixed with the product are critical elements to determining a value for metabolizable energy for a formula. To the extent the rehabilitator measures or packs a dry product differently than the manufacturer, the resultant calculation will be incorrect.

Slight changes in the manufacturing process of milk replacer products can render previously reported calculations obsolete. Since many of the nutrient component percentages and kcal values cited in some of the wildlife rehabilitation literature are no longer correct, rehabilitators should calculate the nutritional content of the milk replacer formulas based on current manufacturer information (Table 2).

FEEDING REGIMEN INTRODUCES UNCERTAINTY

Once a rehabilitator chooses a milk replacer product or combination of products to use, the proper concentration of the formula and feeding frequency must be determined. Some of the published ratios of product to water yield a formula that is too thick for some species, such as tree squirrels, to handle. Many rehabilitators have reported that a

thick, pancake batter-like formula has caused diarrhea, dehydration, and other problems, necessitating dilution of the formula with more water. In most cases, further dilution with water requires the formula to be given more frequently to insure that the proper amount of nutrients are provided to the animal in a 24-hour period. The rehabilitator must work diligently to get an effective combination of product (or products), formula concentration, and feeding frequency to produce appropriate elimination, proper hydration, and healthy and sustained growth and development (physical and behavioral).

ONLINE NUTRITION CALCULATOR

The WildAgain Nutrition Calculator (www.ewildagain.org) is an online, interactive tool for rehabilitators to calculate the nutritional composition and kcal value for substitute milk formulas. The calculator allows a wildlife rehabilitator to enter the desired ratio of dry milk replacer product(s) to water with the calculated result providing the key nutritional components and kcal values. This tool allows the user to put in their own weights for products and water, depending on how each individual may measure out dry products or water. Additional information and cautions are available on the website.

Using the online tool to calculate these numbers should be viewed as just the starting point for determining the best formula to give a particular species. Many factors must be considered, including the age, weight, and condition of the animal, as well as its observed tolerance for a given formula mix and any other ingredients, the concentration of the formula, and the feeding amounts and frequency.

CONCLUSIONS

Nutrition is a crucial component of effective rehabilitation. Wildlife rehabilitators should not just run the numbers for the nutritional content of milk replacer formulas. Many factors can determine the success or failure of a formula. Close observation of animals is needed to assess if a formula is working.

Beware of the cookbooks that make selection of milk replacer products and formulas look easy. It is not. Discuss the product specifications with the manufacturer. Rehabilitators should not just rely on the label on the product (guaranteed analysis). The much more complete typical nutritional analysis should be requested and evaluated prior to use. Regular communication should be maintained with the manufacturer to be alert to changes in the manufacturing process or content of the commercial products.

Table 2. An example of differences in the nutritional and energy content values from the literature (Marcum 1997a, 1997b) and the calculated values using current information provided by the product's manufacturer (PetAg 2001). Nutritional values are expressed as percent of wet matter basis (percent of the mixed liquid formula).

	Percent composition				
	Solids	Fat	Protein	Carbo-hydrate	kcal/cc
Marcum 1997a, 1997b					
1 part Esbilac or Zoologic 33/40					
1 part MultiMilk or Zoologic 30/55	26.7	13.4	8.8	2.1	1.65
2 parts Water					
Per PetAg for Esbilac					
1 part Esbilac					
1 part MultiMilk or Zoologic 30/55	31.0	15.6	10.5	2.7	1.79
2 parts Water					
Per PetAg for Zoologic 33/40					
1 part Zoologic 33/40					
1 part MultiMilk or Zoologic 30/55	32.1	16.0	10.9	3.2	1.86
2 parts Water					
Average percent difference in values	**18**	**18**	**22**	**40**	**11**

Some of the more popular publications are out of date as to the energetic and nutritional content of the commercial milk replacer formulas (Table 2). Check the values in the publication with the product label and, if necessary, obtain the most current values from the manufacturer. Published formulas and product information can be misleading in not providing appropriate cautions to the user as to the factors that need to be considered. The assumptions used in the calculations of published cookbook formulas are in error in some cases (e.g., reporting incorrect values for energy content and nutritional composition).

A feeding regimen that works should be developed. This is the right combination of milk replacer product(s), concentration (strength or dilution), and feeding frequency. Adjustments should be made as necessary to find the right combination. Communication with other

rehabilitators and mammal nutritionists can provide insights into alternative regimens that have proven to be more successful.

Keen observational skills should be developed and used to monitor the animal closely. Regular observations should be made and coupled with notes or records on each animal. Success is assessed as healthy, normal elimination, proper hydration, and sustained and regular development (weight gain, coat development, alertness, behavior, etc.).

The rehabilitation network is an excellent source for information, especially for those rehabilitators from across North America that work with the same species. The membership directories of the National Wildlife Rehabilitators Association and International Wildlife Rehabilitation Council are excellent sources for contact information for other rehabilitators.

As a wildlife rehabilitation community, more research is needed on species-specific nutrition and on which feeding regimens work best and produce consistent and successful results. Rehabilitators need to significantly increase the understanding of nutrition as a major component of effective wildlife rehabilitation and encourage development of resources that are up to date, accurate, and complete. As a community, wildlife rehabilitators should work to insure that literature on mammal nutrition distributed in the community is thoroughly peer reviewed for accuracy and responsible and sound rehabilitation practice.

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