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MICRONESIAN KINGFISHERS: NUTRITION AND DIETARY HUSBANDRY[a]

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Due to the rapid decline of the wild Micronesian kingfisher (*Halcyon cinnamomina cinnamomina*) population on Guam, few data on dietary habits and associated nutrient intakes were gathered prior to establishment of a captive population. Although further information would be very helpful in developing appropriate diets for captive birds, the species is now extinct in the wild. Therefore, the dietary guidelines presented here are based on 1) published accounts of the feeding ecology of this species, 2) food preferences in captivity, 3) availability of accepted food items, and 4) nutrient requirements of other avian species. Recommendations given here are subject to revision as we learn more about the nutritional needs and food preferences of these birds.

Free-Ranging Feeding Ecology

Free-ranging Micronesian kingfishers have been observed feeding primarily on grasshoppers, skinks, annelids, insects, hermit crabs, other small crustaceans,[2] and occasionally small mammals and young birds.[22] During a 1985 nest survey, Marshall observed that several species of skinks, anoles, and

[a] Adapted frrom Crissey, S.D., and B. Toddes. 1998 . Nutrition chapter of the Micronesian Kingfisher Species Survival Plan Husbandry Manual, 1st edition. Published by Zoological Society of Philadelphia.

geckos made up the main part of the diet of a pair of kingfishers raising chicks, although they also ate a variety of insects.[12] Wild prey items were not analyzed for nutrient content nor was there information provided on feeding frequency, feeding preferences, or seasonality of food sources.

Food Preference and Diet Intake

In contrast to the variety of foods in the wild, foods available for captive Micronesian kingfishers are fewer in number and often different in composition. Because of this limitation, it is unlikely that kingfishers will make nutritionally optimal food choices. Among captive mammals, few exhibit evidence of nutritional wisdom,[19] and there is no evidence that birds behave differently. Thus, it is important to offer foods that complement each other nutritionally and to offer them in a way that will encourage consumption of a balanced diet with adequate nutrient concentrations.

In 1994 and 1996, surveys of institutions housing Micronesian kingfishers identified food items offered and assessed food intakes. Birds housed singly consumed about 12 g (as fed) of food per day, whereas daily food consumption by pairs was 20 to 38 g. Both surveys indicated that kingfishers have a strong preference for whole food items (e.g., anoles, mice, or insects) compared to prepared commercial diets (e.g., dry dog or cat food or meat-based bird diets). The nutrient density of whole prey is variable both among and within species (Table 1). Thus, the prey items offered and consumed have a significant impact upon actual nutrient intake. Diets offered appeared high in energy, fat, protein, vitamin A, and iron, but low in vitamin E, with potentially inverse calcium to phosphorus ratios when insects were a major fraction (Table 2).

All Micronesian kingfishers received either fuzzy or pink mice. These comprised the largest proportion of total offered dietary wet weight, with insects, as a group, in second place. When green anoles (*Anolis carolinensis*) were fed, nearly 100% were consumed, suggesting that if they were offered at higher levels, their proportion of dietary wet weight would have been higher as well.

Nutrient Intakes

Protein

The protein content of the foods offered to the kingfishers ranged from 30–68% of dietary dry matter (DM) (Table 1). The actual level of protein in insects, after correction for the nitrogen contained in the chitin of the exoskeleton, should be reduced by approximately 10%.[1] Although an amino acid profile of the foods used in kingfisher diets was not determined, proteins from animal sources with known profiles contain a generally adequate array of essential amino acids. Because the level of protein in the Micronesian kingfisher diets exceeded the requirements of both cats and poultry,[15,18] it is likely that the kingfisher's protein and essential amino acid requirements would be met.

Fats and fatty acids

Fat is important in the diet for energy, as a carrier for fat-soluble vitamins (A, D, E, and K), and to supply essential fatty acids. The essential fatty acids, linoleic acid (18:2, n-6) and ? -linolenic acid (18:3, n-3), are required because they cannot be produced endogenously. Although deficiencies of these fatty acids are not common, a deficiency of linoleic acid can result in decreased resistance to disease, impaired sperm production, and abnormal embryonic development. One percent linoleic acid in the diet will prevent these problems in poultry.[18] Items used in kingfisher diets (Table 1) appear to contain enough fat as a source of energy to support maintenance, growth, and reproduction, and analyses of pink mice show that, in general, mice are excellent sources of essential fatty acids.[5]

Vitamins/minerals

While all nutrients accepted as essential for other species are presumed important to the health and wellbeing of kingfishers, only those that may be related to problems observed in the captive Micronesian kingfisher population (as reported by SSP participants) are considered here.

Vitamin A. Although vitamin A deficiencies have not been reported in Micronesian kingfishers, vitamin A deficiencies in domestic poultry lead to decreased growth, loss of appetite, weakness, staggering, and ruffled feathers. In addition, susceptibility to infections increases, whereas egg production and hatchability are reduced. Abnormal eye exudate and drying of the eyes also have been observed.[11] Maximum tolerances for vitamin A in poultry are 10 to 30 times the requirement of 1.1-4.4 IU/g of dietary DM.[18] Since Micronesian kingfishers naturally consume animal matter that may contain high levels of vitamin A, their tolerance may be higher than that of poultry, although actual tolerance limits are unknown. Vitamin A levels in pink mice and green anoles exceed domestic poultry requirements for growth by 9-18 and 6-11 times, respectively, whereas insects provide less than 73% of the vitamin A level required by poultry (Table 1).

Vitamin E. There were three reports of myopathy or myocardial degeneration in Micronesian kingfishers from 1986-1991 that may have been related to deficiencies of vitamin E/selenium, but none have been reported since. The need for vitamin E is influenced by the levels of other nutrients in the diet. When a diet high in polyunsaturated fatty acids is low in vitamin E, encephalomalacia (necrosis of the cerebellum) may occur in domestic poultry. When selenium and vitamin E are both deficient, exudative diathesis (increased capillary permeability resulting in subcutaneous edema) occurs. Degeneration of the testicular epithelium has also been reported as a sign of vitamin E deficiency in chickens.[11]

Vitamin E tolerance is 100 times the requirement for domestic poultry.[18] It should be noted that high dietary concentrations of vitamin A have been shown to depress vitamin E status in both mammals and chickens,[8] indicating that nutrient interactions may significantly influence nutritional requirements. The mechanisms of this interaction, while unknown, may be related to the destruction of vitamin E as it protects vitamin A from oxidation. Extrapolating to species other than domestic poultry is problematic since there are differences in the response to vitamin E deficiency even among domestic poultry species.[11]

Vitamin E concentrations appear to be moderate to low in adult mice, pink mice, and insects, and near undetectable to moderate in green anoles (Table 1). Storage of green anoles for >6 months by the standard method (euthanasia followed by freezing) may lead to degradation of vitamin E although this has not been tested directly. Thus, given low vitamin E levels and high vitamin A and fat levels in the diet, vitamin E deficiency could become a problem.

Carotenoids. Although it was once thought that carotenoids served only as precursors to vitamin A, more recent studies suggest that carotenoids, particularly ?-carotene, may influence immunity and reproduction.[4,20] Carotenoids also play a well known role in tissue pigmentation.[3] In domestic poultry, lutein, zeaxanthin, and some ?-carotene contribute to the yellow color of skin and egg yolk.[18] In the laying hen, 50% of the body's zeaxanthin is found in the ovary.[18] Carotenoids in the diet of the Micronesian kingfisher include lutein + zeaxanthin, ?-cryptoxanthin, and ?-carotene in concentrations that were much greater in green anoles than in other foods (Table 1). Carotenoids were undetectable in pink mice. It should be noted that carotenoids are naturally present in some crustaceans[20] and possibly other lizards. Although carotenoid levels in diets consumed in the wild are unknown, the types of prey reported to be consumed are likely to include carotenoid-containing species.[2] While the roles of carotenoids in the diet of the Micronesian kingfisher are presently unknown, the possibility that they may be important should not be overlooked.

Vitamin D, calcium, and phosphorus. Vitamin D, calcium (Ca), and phosphorus (P) are nutrients with interrelated functions.[11] In general, the function of vitamin D is to sustain plasma calcium and phosphorus at levels that will support normal mineralization of bone and maintain other body functions requiring these nutrients.[13] Signs of Ca and vitamin D deficiency in domestic poultry include thin-shelled eggs, lowered egg production, decreased hatchability, and bone deformities. Poultry use vitamin D_3 (cholecalciferol) more effectively than vitamin D_2 (ergocalciferol),[18] the former originating primarily from animal sources, the latter primarily from plant sources. Maximum tolerance for vitamin D_3 in poultry is 4-10 times the requirement of 0.2-0.5 IU/g dietary DM,[18] with excessive levels of vitamin D causing mineralization of soft tissues.

Insects appear low in Ca, although Ca supplements in the insect diet may increase Ca concentrations significantly (Table 1). Insect samples in this study were taken from five institutions and all may not have been fed a high-Ca insect diet for the appropriate number of days under appropriate conditions for maximum Ca intake. The Ca content of vertebrates appears adequate, although an occasional inverse ratio of Ca:P was found in some of the samples analyzed. These Ca concentrations are similar to some values published for rodents, but in that report, the levels of P were not reported.[6] Additionally, these concentrations are substantially lower than those reported at the Comparative Nutrition Laboratory at Michigan State University (Ca 3.8 % for juvenile mice, 2.8-2.9% for pinkies) (Ullrey, pers. comm.). These differences may be due to the age of prey, diet fed, or type/breed of prey item. The ideal ratio of Ca:P has been proposed to be 1:1 or greater for adult animals at maintenance, although certain mammalian carnivores seem to tolerate moderate inverse ratios quite well.[7,14] Large amounts of P in relation to Ca have been reported to cause bone loss in some animal studies.[9,10] While the actual Ca content of the vertebrates and manufactured diets was at least adequate compared to domestic poultry requirements (with one analysis for green anoles being very high), concern has been raised that if the Ca:P ratio is not at least 1:1, Ca metabolism problems may occur, particularly during production of multiple clutches of eggs.

Vitamin D concentrations were <1 IU/g DM in all food items except large mealworms and green anoles, the latter being by far the highest. However, the minimum detection limit of the analysis was above target nutrient levels, and it is possible that all food items were adequate in vitamin D. It is evident that green anoles contained adequate to high vitamin D concentrations. The level reported for mighty mealworms was high, but only one sample was analyzed. The chemical analysis for vitamin D is difficult, and analytical precision varies appreciably.

Iron. Excessive iron storage in the livers of some Micronesian kingfishers has been reported, but iron deficiency also can cause problems, such as anemia and reduced hatchability of eggs. Birds lose iron through egg production and feather loss, and adequate levels of iron must be provided to support reproduction. The maximum tolerable levels of iron for domestic poultry are 1,000 mg/kg dietary DM.[16] The analyzed values for Micronesian kingfisher foods averaged 150 mg/kg DM (although some meat-based diet samples were higher), which should be adequate without being excessive. Water and soil ingestion also is a potential source of iron intake and should be quantified if iron accumulation continues to be a problem.

Diet Recommendations

Diet formulation

Appropriate diets for Micronesian kingfishers can be formulated using National Research Council (NRC) nutrient requirement guidelines, historical reports of foods consumed in the wild, and nutrient concentrations in food items available for captive feeding. Ranges of desirable dietary nutrient levels are provided, based on NRC requirements for both domestic fowl[18] and carnivorous mammals,[15,17] given that these are carnivorous/ insectivorous birds (Table 3).

Because of differences in weight, exercise, physical condition, environment, food availability and preference, and psychological/social behavior, some flexibility is needed when formulating diets for Micronesian kingfishers. Therefore, dietary guidelines for nutrient content and suitable foods have been provided, allowing for formulation flexibility while assuring that the diet will be nutritionally adequate when consumed.

If consumed in its entirety, the recommended diet should contain the nutrient concentrations presented in Table 3 per unit of dietary DM. These should be considered target nutrient levels until more specific requirements are established. Table 4 presents a formula for a recommended diet for Micronesian kingfishers in percentages by weight, as fed. The amounts of food to offer, and expected consumption of individual food items also are presented.

Schedule of feeding

Care must be taken to schedule feeding in synchrony with the animal's habits, not the care-giver's preferred routine. The quantity fed at a time should correspond to natural feeding activity. For example, the morning (or most active feeding period) offering should include more food than that in the afternoon (less active feeding period). The current recommendation is to feed birds twice per day. It is not appropriate to leave food out at night because of spoilage and nutrient losses, as well as pest infestation. It is preferable to provide fresh food in the early morning hours when the birds begin feeding. Water should be provided at all times.

Recommended diet

In zoos, the diet items offered are often restricted to items available commercially. The items most commonly offered and accepted are mice of various age and size categories, insects, green anoles, and some commercially available manufactured products. The specific diet recommendations are based on these items, as well as the nutritional analyses of prey (Tables1 and 2). These recommendations should support the target nutrient values with respect to protein, fat, and energy (Table 3).

In the past there have been supply problems with green anoles since they are wild-caught. For this reason, green anoles are often purchased in bulk when available, and there may be nutrient degradation during long-term storage. Concerns have also been raised regarding the potential for parasite transmission from wild-caught green anoles. Freezing anoles will kill many parasites, and to date there have been no reports of parasite transmission from anoles to kingfishers. One storage protocol that allows for thorough freezing and decreases dehydration is euthanasia followed by freezing individual anoles in a small plastic bag containing 200 ml water. Refer to Micronesian Kingfisher Husbandry Manual for details.

Prey items (mice, lizards, and insects)

The intake data collected on these species strongly suggest that kingfishers will readily accept almost any whole prey item offered. Since these prey items exhibit a compositional variability typical of most biological organisms, there may be differences in nutrient content among individuals. The nutrient content of some prey items can be altered by manipulating the diet of the prey animal itself (e.g., by feeding a high-Ca diet to mealworms, wax-moth larvae, or crickets).[1] However, the ability to correct all nutrient imbalances of prey through manipulation of their diets is limited. For this reason and because reproductive problems, including poor egg quality, have been reported for Micronesian kingfishers, inclusion of a nutritionally complete manufactured diet is recommended.

Not addressed in detail is the behavioral component of diet composition. It has been suggested that courtship behavior can be stimulated by the presence of live whole prey items, especially green anoles. If this proves to be true, seasonal variations in diet composition may be appropriate. Live prey items (e.g., crickets) also may stimulate natural feeding behaviors. Because the goal of captive breeding is the eventual reintroduction of Micronesian kingfishers into their natural habitat, efforts to stimulate natural feeding behavior are important to reintroduction success.

Manufactured diets

A commercial diet that is readily accepted by adult kingfishers has not been identified. If birds are exposed to a manufactured diet at a very early age, however, they may be more inclined to consume it. Offering items such as moistened dry cat food or a nutritionally consistent meat-based product is recommended at 20% of the diet, as fed. Please note that the meat-based bird diet analyzed in this study was not nutritionally consistent, particularly in vitamin A concentration (which can be toxic in excess), as well as in fat and energy. In fact, fat concentrations were twice as high in some samples as compared with others of the same product. Some of these fluctuations were more extreme than the fluctuations found in composition of whole prey. Thus, it is recommended that the nutritional consistency of any meat-based diet be monitored. Furthermore, the quantity of a manufactured diet that is eaten should be monitored in relation to consumption of other items to ensure that expected nutrient intakes will be achieved.

Supplements

Because of potential nutritional inadequacies in a whole prey diet and the marginal acceptance of nutritionally complete commercial diets, supplementation is advisable. The current recommendation is supplementation with Ca and vitamin E.

Calcium. Calcium supplementation of insects offered as prey (both mealworms and crickets) involves feeding the prey a commercial insect diet containing at least 8% Ca, on a DM basis. Several appropriate products are currently marketed: Insect Supplement by Marion Zoological, Inc., Plymouth, MN; Mazuri 5M38 by Purina Mills, Inc., St Louis, MO; Cricket Diet, formula 53900000 by Zeigler Bros., Inc., Gardners, PA. The high-Ca diet should be fed for 3 days while the insects are held at 80? F and water is supplied as a source of moisture.[23] Dusting insects with a Ca source is not recommended because self-cleaning and loss during movement results in great variation in the amount of Ca adhering to the insect until eaten. The Ca dust also may adversely affect acceptability of the dusted insect by kingfishers.

Use of the recommended diet (Table 4) will ensure that proper nutrient levels and Ca:P ratios are maintained. When there are deviations from recommended dietary items, adjustments may be needed so that at least 0.7 % but not over 2.5% Ca will be present in dietary DM. The use of supplements must be controlled because too little or too much can have adverse effects. When used, supplements should always be added in measured or weighed amounts.

Vitamin E. Because tolerance to excess vitamin E is high and the levels present in the recommended diet are low, supplemental vitamin E can be provided at the target levels without adverse effects. Vitamin E is available both as a dry powder and as a liquid oil suspension. The appropriate amount of supplement can either be dusted over the diet (dry powder) or injected into a food item (oil suspension). When using the recommended diet (Table 4), a daily supplement of 0.6 mg of all-*rac*-?-tocopheryl acetate per 12 g diet (as fed) should be sufficient. Since vitamin E is a fat-soluble vitamin which can be stored in the body, it can be supplemented periodically at a more practical level. For example the vitamin E supplement might be given twice per week at about 2 mg. Care should be taken to determine the potency of the supplement administered to ensure that dosage is correct.

Diet reassessment and adjustment

Because these diet recommendations are based upon preliminary research, continued reassessment of the adequacy and acceptance of the diet will be necessary. In addition, if one food item is substituted for another, or if food intake changes, reassessment of the entire diet may be necessary. Other factors potentially affecting the need for diet reformulation are individual food preferences and body weight fluctuations.

Weight problems are not uncommon among captive Micronesian kingfishers, particularly a tendency towards obesity. Diets may also require adjustment seasonally. For example, green anoles can be increased to 50% of the diet (as fed) combined with 10% crickets and 40% pink mice, during the breeding season. When green anoles are scarce or it is not breeding season, the proportion of lizards in the diet can be reduced. It is advisable, however, to include green anoles in the diet at least weekly throughout the year because of their carotenoid and vitamin D content.

Increasing or decreasing the proportion of calorically dense food can aid in maintaining appropriate body weights. Any dietary intake changes should be made slowly, starting with a 5% change in the amount of food offered. For example, substituting the same quantity by weight of crickets for mealworms will provide the animals with less energy (Table 1). It is important to monitor weights when dietary alterations are made, although weighing frequency should not exceed once per month to avoid subjecting the birds to undue stress. Weight records also will provide a measure of seasonal weight fluctuations that could be 'normal' for a particular bird. Carefully kept records with respect to diet alterations and their effects are basic to defining the most appropriate captive diets for the Micronesian kingfisher.

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Table 1. Ranges of nutrients (DM basis) in items offered to Micronesian kingfishers (as chemically analyzed).

Nutrient	Pink mice n=5[a]	Anolis lizards n=3	Juvenile mice n=1	Crickets n=5	Mealworms n=4	Large meal-worms n=2	Meat-based diet n=3	Cat food n=1
Dry matter, %	19-27	25-29	26-27	31-41	37-41	38	35-38	93
Crude protein, %	47-61	65-68	52-56	60-66	47-52	46	44-50	30
Fat, %	15-38	8-10	13-33	11-14	27-36	37	15-31	8
Gross energy, kcal/g	5.3-6.3	4.7-4.8	5-6	5.5-5.6	6.1-6.4	6.4	4.3-6.2	5
Vitamin A, IU/g	13-28	9-17	9-257	0.9-1.1	0.3-0.4	nd	3-96	10
Vitamin E,[b] IU/kg	6-10	0-18	4-7	5-76	9-24	0.3-0.7	17-30	137
Vitamin D, IU/g	nd[e]	3.8-8.5	nd	nd	nd	4.7	-[f]	-[f]
Leut+zeax,[c] ?g/100g	nd	1882-3299	nd	5-138	14-74	5.5-5.7	76-96	216
?-Crypt,[d] ?g/100g	nd	362-498	nd	3-8	4-14	1.8	13-18	0.14
?-Carotene, ?g/100g	nd	nd	nd	2	3-117	9-26	3-15	4.3
?-Carotene, ?g/100g	nd	1.6-2.4	nd	0.07-7.5	0.08-1.9	0.23-1	1.3-2.3	0.14
Ca, %	1.2-1.6	2.3-4.7	0.8-2.3	0.05-0.44	0.06-0.16	0.04-0.05	0.7-1.1	1.2
P, %	1.5-1.8	2.6-2.8	1.7-2	0.9-1.0	0.84-0.91	0.58-0.74	0.9-1.1	0.85-0.92[g]
Mg, %	0.1-0.13	0.13-0.18	0.09-0.13	0.1-0.15	0.13-0.25	0.13-0.14	0.06-0.1	0.1[g]
K, %	1-1.5	1-1.2	1-1.2	1.2-1.3	0.67-0.92	0.59-0.62	0.6-1.2	0.89-1[g]
Na, %	0.5-0.9	0.5	0.4-0.5	0.4	0.11-0.15	0.12-0.15	0.3-0.4	0.22-0.25[g]
Fe, ppm	126-258	129-151	133-319	54-68	45-66	39-58	7-507	278-283[g]
Zn, ppm	60-92	24-36	70-93	75-191	130-167	88-92	90-96	197-218[g]
Cu, ppm	1-21	1-2	12-15	21-23	14-20	13-18	8-13	22-25[g]
Mn, ppm	nd-5	2-5	2-17	34-42	8-14	5-9	37-50	66-70[g]
Mo, ppm	2.3	nd	nd	0.4-0.6	0.8-1.2	0.3-0.8	0.4	0.3-1.8[g]

[a]Number of zoos submitting samples. Samples represent frozen foods submitted from 6 institutions participating in the 1996 diet survey. See Micronesian Kingfisher Husbandry Manual for detailed sample analysis protocol.

[b]Alpha-tocopherol.

[c]Lutein + zeaxanthin.

[d]Beta-cryptoxanthin.

[e] nd = not detectable or below minimum detectable level.

[f] = not analyzed

[g]Represents multiple tests of one sample.

Table 2. Average dry matter, protein, and gross energy density (DM basis) of the diet consumed by Micronesian kingfishers (1996 survey results; computer analysis N2 Computing).

Nutrient	Range
Dry matter, %	24 - 33
Protein, %	55 - 56
Gross energy, kcal/g	5.5 - 6.1

Table 3. Nutrient target levels in diet, DM basis.

Nutrient	Concentration
Gross energy, kcal/g	4-7
Crude protein, %	20-25
Fat, %	18-28[a]
Vitamin A, IU/g	1.67
Vitamin D, IU/g	0.22-0.5
Vitamin E, mg/kg	5-80
Carotenoids, mg/kg	Unk[b]
Calcium, %	0.78-2.5[c]
Phosphorus, %	0.33-0.44
Magnesium, %	0.056
Potassium, %	0.333
Sodium, %	0.167
Iron, mg/kg	67-80
Zinc, mg/kg	39-50
Copper, mg/kg	6.7
Manganese, mg/kg	33-44
Cobalt, mg/kg	-
Selenium, mg/kg	0.11-0.16

[a]This is not a requirement for fat but represents the range of fat in kingfisher diets in captivity. This range is thought to be appropriate, will supply essential fatty acids, and will promote fat-soluble vitamin absorption.

[b]There is no known requirement for carotenoids. However, given that anolis lizards contain quite high levels (mean of about 2,600 ? g/100g, DM basis), and carotenoids contribute tissue color, these compounds should be considered when feeding kingfishers.

[c]The higher level may only be appropriate for females laying multiple egg clutches and then, only for a very limited period of time. What is possibly more important is a 1.2:1 to 2:1 Ca:P ratio in the diet for all birds.

Table 4. Recommended diet for Micronesian kingfishers.

Food item	% (as fed) by weight	Range to feed, g per bird	Range to feed, g per pair[a]	Expected consumption (single birds)[b]
Pink mice	25-50%	3-6	10-20	77-100%
Green anoles[c]	25-50%	3-6	10-20	100%
Insects[d]	20-30%	2.4-3.6	8-12	>80%
Dry cat food[e]	0-20%	0-2.4	0-8	na[f]
Supplements	see below[g]			
Total diet		12 g	40 g	

[a]For pairs with chicks a portion of the offered pink mice and green anoles should be chopped and total diet amount should be increased by 25% per chick in nest. Care should be taken to keep the ratio of each dietary item offered consistent with the table.

[b]Actual consumption may differ depending on caloric density of the diet and energy needs of the individual. Foods selected can be based on availability and seasonality.

[c] During courtship, incubation, and chick-rearing, feed green anoles at upper level (50%). The Combined quantity of pink mice and green anoles should not exceed 75% of the diet.

[d]Insects (crickets, mealworms, mighty mealworms or wax-moth larvae) should be fed a commercial cricket diet which contains at least 8% Ca (DM basis) to improve the Ca:P ratio. Care should be taken to keep crickets at 80 ? F to encourage adequate diet consumption.[23] Insects should comprise at least 20% of the diet.

[e]Cat food should be offered, especially during chick-rearing and fledging (see text). It can be soaked or presented in such a way as to encourage consumption. The cat food should contain nutrient concentrations (DM basis) of 30% protein, and 8% fat (see Table 1).

[f]Consumption of manufactured diets must be monitored.

[g] Calcium: for birds consuming 12 g of a combination of mice, crickets, and green anoles; supplement crickets with an insect supplement containing 8% Ca for 3 days prior to feeding.
Vitamin E: 0.6 mg of vitamin E per day.