OBESITY, WEIGHT MANAGEMENT AND DIETARY ANALYSIS IN MICRONESIAN KINGFISHERS (*HALCYON CINNAMOMINA CINNAMOMINA*).

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Abstract

Mortality in captive Micronesian kingfishers (*Halcyon cinnamomina cinnamomina*) is notably high in age classes that should be peak breeding years. Females, in particular, suffer high rates of mortality earlier than would be expected from examining patterns in related species. Many birds are overweight and sustained weight loss has been difficult to achieve. Body mass for the 2.2 birds in this project were manipulated through bi-weekly weights and diet adjustments in an attempt to keep body masses at less than 65g. Body mass reductions occurred through dietary manipulations for two birds. However, body mass reductions in two other birds appeared to be more a result of location changes and either the stress related to that move or the reduction in available "extra" food items than dietary manipulations. Proximate composition of food items was similar to that previously published. Cholesterol levels in anolis lizards were similar to previously published data on pink mice, whereas cholesterol in cat food and crickets were roughly half that of the vertebrate prey. Fatty acid content of the food items likewise varied. Anolis lizards had the lowest total fatty acid content and the fatty acids were relatively evenly divided among saturated, monounsaturated and unsaturated fatty acids. Pinkie mice were highest in saturated fatty acids, while mealworms were highest in both mono- and polyunsaturated fatty acids and had the highest overall fatty acid content.

Introduction

Guam's subspecies of Micronesian kingfisher (MKF) were driven to extinction in the wild by the introduced brown tree snake, and this kingfisher now persists only as a population of about 65 birds in U.S. zoos. Mortality is high in age classes that should be peak breeding years. Females, in particular, suffer high rates of mortality earlier than would be expected from examining patterns in related species. Another problem that has persisted in the population is that many birds are overweight and sustained weight loss has been difficult to achieve. Patterns of mortality and poor weight control have been examined in the Brookfield Zoo population. While no pattern was detected connecting obesity with family lineages, ages, or seasonality, it did become clear that adult females have higher mean weights and are more often "overweight" than adult males.

The issue of weight management in kingfishers has been discussed for several years, but previously the critical risk of obesity was not recognized. We have noted a possible relationship between obesity and egg yolk peritonitis in female Micronesian kingfishers and the possible effect of dietary lipid profile on health. Thus, the specific goals of this study are: 1) to closely monitor energy, protein and fat intake and correlate it with body mass changes, and 2) to evaluate the lipid profiles of crickets, mealworms, anolis lizards and cat food.

Methods

Body Mass changes

Bird Department staff recorded daily intake data for each bird beginning in November 2002. Daily intakes were determined by weighing each food item prior to feeding and weighing back food remaining. Birds were housed separately and weighed approximately every two weeks once they became part of the study. Criteria for inclusion was a body mass that remained above the goal range of 56-64g based on weights of wild males.[9] Diets offered the MKF over the course of the study are outlined in Table 1. One bird (990143) required additional diet alterations beginning week 10 in order to reduce his weight to the desirable 65g maximum. MKF 360 and 990143 are included only up to week 19 when they were paired for the breeding season and individual tracking of diet consumption became impossible.

Diet Composition

Representative samples of crickets and mealworms were obtained from the Bird Department and frozen at -80°C until analysis. Samples of frozen anolis lizards and dry Iams Less Active cat food (The Iams Company, Dayton, OH) were obtained as well. Analyses for dry matter (forced draft oven, 60°C), crude protein (nitrogen by Kjeldahl x 6.25), crude fat (Soxhlet ether extraction, AOAC Method 960.39, modified) and energy by bomb calorimetry were performed in the Brookfield Zoo Nutrition lab. Samples were analyzed for cholesterol and fatty acids as triglycerides by Covance Laboratories, Inc (Madison, WI) using AOAC Method 994.10 (modified) and AOCS Method Ce 1-62 (modified), respectively. Nutrient information for 3-5 gram pinkie mice was obtained from previous analyses conducted at Brookfield Zoo.[5,6] Energy intakes for each bird were calculated by multiplying the grams of each food item consumed by the analyzed caloric content of each food item and summing across food items for each day.

Results and Discussion

Body Mass Changes

Data from free-ranging populations of kingfishers on Pohnpei, an island neighboring Guam (*Halcyon cinnamomina reichenbachii*), indicate these birds may consume a greater portion of their diets as insects rather than vertebrate prey as was previously thought. This subspecies of MKF has been observed collecting grasshoppers, centipedes, moths and other invertebrates rather than lizards. Additionally, casting pellets collected by researchers were composed primarily of beetle and grasshopper exoskeletons.[8] Based on these observations, the ratio of crickets:pinkies was increased in the weight loss diet compared to the original diet. In addition to altering proportions, overall quantity offered was reduced. Table 2 compares dry matter, protein, fat and energy content among the diets. Weight loss diet 1 was the highest in protein and lowest in fat of the diets. While both diets 1 and 2 reduced calories, diet 2 was the lowest in energy.

Body masses of the birds were compared to caloric intake over time in Table 3. MKF 360 lost weight slowly over time despite variations in energy intake. The male of this pair, 990143, showed some interesting changes over the course of the study. At week 13 this pair was moved from a basement enclosure to an off exhibit area on the main floor of the building. Up to this point, his weight had been maintained between 70 and 75 grams despite dietary alterations. Once the birds were moved, there was a rapid weight loss for 990143 with changes in the diet offered. Because of the weight loss 990143 was returned to weight loss diet 1, which is higher in both quantity and caloric content. We suspect this bird frequently consumed the free-ranging geckos and roaches known to live in the basement and thus was consuming more calories than accounted for by the prescribed diet. Interestingly, we did not see this rapid weight reduction in the female, 360, housed adjacent to him. MKF 961 joined the study during Week 9 due to weight gains. MKF 961 and 962 did not show weight gains when moved to the basement. MKF 962 lost weight shortly after the move, then regained weight. Near the housing change at week 13, MKF 961 was near the bottom of the goal range and diet changes were implemented to return him to the appropriate range. It would appear that availability of other food sources can have a great affect on the body mass of an individual and every effort should be made to remove animals with weight issues from these situations. Changes in location can also be a stressor and may cause weight reduction. Birds should be weighed on a regular basis to monitor body mass changes.

Diet Composition

Selected nutrient composition of the food items fed to BZ MKF is presented in Table 4. Anolis lizards are highest in crude protein at 65.38%, while the cat food was the lowest at 29.28%. It should be noted that crickets and mealworms contain chitin (non-protein nitrogen) as part of the exoskeleton, which can artificially elevate protein values. Chitin digestibility has been shown to vary among mammal species, however this nitrogen is not thought to be available for use by the animal.[1] Fat was highest in the mealworms and pinkies and lowest in the cat food. On a dry matter basis, mealworms are the most energy dense, followed by pinkies and crickets. Published data for anolis and other lizards show similar nutrient composition, however fat content of the anolis in this study were somewhat higher.[4,6] Data for pinkie mice are similar to that previously published for neonatal mice in this weight range.[7] Composition of crickets and mealworms are similar to that previously published, however the mealworms in this study are slightly lower in protein and higher in energy[1,6]. Protein for all prey items is above the target nutrient levels for MKF of 20-25 %, however protein may be overstated for insects due to the chitin content. Fat content of pinkies and anolis are above the established target nutrient levels, while energy content of all items is appropriate.[6]

Cholesterol levels in vertebrate prey items were 2.5-8.3 times higher than those of the invertebrate prey. Cholesterol levels in pinkies were similar to those previously published for pinkie mice.[5] Little information exists detailing the fatty acid composition of various prey items.[5,7] Fatty acid requirements have yet to be established for this species, however fatty acids play an important role in immune function, brain development reproduction and vision.[2,3,10,11] While fatty acids levels presented are the result of one repetition at this time, some generalities can be noted. Pinkies are highest in fatty acids in nearly every category, in many cases greater than ten times that of other prey items. Mealworms were highest in oleic and linoleic acids compared to other prey items and were second in 6 other fatty acid categories. Since mealworms and pinkies have the highest fat content of the prey items, this is not surprising. Generally, the levels of fatty acids as triglycerides in cat food were less than 2 g/100g. Exceptions include the saturated fatty acids palmitic and stearic acid, which were greater than 2 and 6g/100g in all categories. Anolis lizards had low total fatty acid content and the fatty acids were relatively evenly divided among saturated, monounsaturated and unsaturated fatty acids. Pinkie mice were highest in saturated fatty acids, while mealworms were highest in both mono- and polyunsaturated fatty acids, and had the highest overall fatty acid content.

Conclusions

Body mass in captive MKF should be controlled by careful monitoring of diet consumption coupled with regular weights. Pathology reports have shown reproductive tract issues such as yolk peritonitis and complications of obesity concurrent with liver disease as body masses climb above 65g. These issues can have a large impact on the survival of the species with regards to longevity of females and reproductive success.

Fatty acid profiles of prey items consumed by MKF should be investigated further. Fatty acid profiles of foods consumed by the Guam subspecies of MKF can no longer be obtained due to the population existing only in captivity. Hopefully, the population of kingfishers on Pohnpei and the ongoing research there will provide us with important data regarding the lipid profiles of foods consumed by wild birds. These data may allow us to alter dietary components for captive MKF to better reflect the lipid profile of the diet consumed by the wild subspecies of kingfisher. These adjustments have the potential to positively impact obesity-related health concerns for captive MKF.

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Table 1. Diets offered Micronesian Kingfishers at Brookfield Zoo (per bird, per day, as fed).

Item	Original diet	Weight loss diet 1[1]	Weight loss diet 2[2]
Cricket[3]	4-6 g	6 g	5 g
Pinkie mouse (3-5g bwt)	7-8 g	5.43 g	6
Anolis lizard	4 g 1x/week	4 g 1x/week	4 g 1x/week
Iams Less Active Cat	0.8-1.0 g	1.0 g	1.0 g
Vitamin E Supplement	0.04 ml 1x/week	0.04 ml 1x/week	0.04 ml 1x/week
Total	14.2g	13.01g	12.6g

[1] MKF 360, 961 and 962 were offered Diet 1 the entire study. MKF 990143 was offered Diet 1 week 0-9 and 18+.

[2] MKF 990143 required additional diet changes in order to reduce weight below 65g beginning week 10 and continuing through week 17.

[3] Isocaloric quantities of mealworms were occasionally offered in place of crickets.

Table 2. Selected nutrient composition of diets offered Micronesian Kingfishers at Brookfield Zoo, Dry Matter Basis.

Nutrient	Original diet	Weight loss diet 1	Weight loss diet 2
Dry Matter, %	31.76	33.92	33.41
Crude Protein, %	52.99	53.06	52.26
Fat, %	19.7	17.6	18.31
Energy, Kcals/g diet	5.58	5.37	4.91

Table 3. Mean energy intake and weight variations in Micronesian Kingfishers* over time.

	MKF 961		MKF 962		MKF 360		MKF 990143	
	Kcals/day	Weight, g	Kcals/day	Weight, g	Kcals/day	Weight, g	Kcals/day	Weight, g
Time 0						68.10		71.10
Week 1		59.70	18.61	68.10	14.83		14.68	
Week 3		67.40	19.43	67.10	16.17	65.23	14.56	71.37
Week 5			18.68		15.29		15.68	
Week 7			18.59	64.34	17.36	66.79	16.87	76.18
Week 9	15.23	65.00	17.02	63.70	17.94		15.72	
Week 11	16.56	62.10	17.75	62.80	16.73	66.94	15.02	74.00
Week 13	19.30	58.10	18.78	59.40	16.02	63.35	15.99	71.95
Week 15	17.94		17.93		16.97		16.37	
Week 17	18.04	57.60	17.89	53.90	17.67	64.80	16.74	60.20
Week 19	19.18	59.10	19.14	54.90	18.78	64.00	18.45	57.80
Week 21	19.58	59.30	19.64	57.00		62.30		58.80
Week 23	18.70	62.50	19.18	61.00				

*Females are MKF 360 and 962. Males are MKF 961 and 990143

Table 4. Selected nutrient composition of food items consumed by Micronesian Kingfishers.

Nutrient	Crickets	Pinkies	Anolis	Mealworms	Iams L.A.Cat
Dry matter, %	31.93	23.9	26.88	40.90	93.98
Crude Protein, %	59.28	53.33	65.38	45.78	29.28
Crude Fat, %	12.00	29.00	11.45	35.14	6.82
Energy, Kcals/g	5.53	5.68	4.88	6.69	4.88
Cholesterol, mg/100g	332	994	848	120	137
Fatty Acids as triglycerides	g/100g				
Saturated fatty acids					
Capric 10:0	0.04	0.25	0.01	0.04	0.01
Lauric 12:0	0.02	1.27	0.04	0.21	0.01
Myristic 14:0	0.09	2.47	0.19	1.47	0.09
Pentadecanoic 15:0	0.02	0.04	0.03	0.03	0.01
Palmitic 16:0	3.66	8.70	2.40	4.61	2.41
Heptadecanoic 17:0	0.06	0.5	0.07	0.03	0.02
Stearic 18:0	1.36	1.26	1.04	0.77	0.65
Arachidic 20:0	0.05	0.02	0.07	0.02	0.01
Total SAT	5.16	13.22	3.71	6.86	3.06
Monounsaturated fatty acids					
Myristoleic 14:1	0.01	0.08	0.01	0.01	0.01
Heptadecenoic 17:1	0.03	0.5	0.04	0.01	0.02
Oleic 18:1ω9	3.76	7.16	4.09	14.47	4.03
Palmitoleic 16:1ω7	0.17	1.29	0.35	0.90	0.66
Eicosenoic 20:1	0.03	0.15	0.07	0.04	0.09
Total MUFA	3.82	9.18	4.39	14.74	4.62
Polyunsaturated fatty acids					
Linoleic 18:2ω6	5.60	6.42	2.19	9.66	2.16
Eicosadienoic 20:2	0.01	0.29	0.03	0.02	0.01
Arachidonic 20:4ω6	0.05	0.89	0.53	0.01	0.10
Alpha linolenic 18:3ω3	0.18	0.31	0.26	0.31	0.10
Eicosapentaenoic 20:5ω3	0.06	0.05	0.07	0.01	0.05
Docosahexaenoic 22:6ω3	0.01	0.33	0.30	0.01	0.07
Total PUFA	5.67	8.42	3.31	9.56	2.41