AEMV Forum

# Comparison of Commonly Used Diets on Intake, Digestion, Growth, and Health in Captive Sugar Gliders (*Petaurus breviceps*)

*Ellen S. Dierenfeld, PhD,*
*Debra Thomas, DVM,*
*Robin Ives, BS*

Sugar gliders (*Petaurus breviceps*) have recently been gaining popularity in the United States as exotic companion animals. Being native to Australia, they have a more extensive history as a captive species in that country. Although not kept as pets in Australia, they are maintained in a number of zoological facilities and wildlife rehabilitation facilities. Sugar gliders have also been used in research as laboratory animals. They are aptly named; they subsist on a diet of nonfoliage plant materials and some invertebrates, using simple sugars in saps, manna, and nectars for energy. Sugar gliders also eat resins, honeydew, lerp (insect exudates), and plant gums—the latter comprising polysaccharides that form gels. Their minimal protein requirement is primarily derived from pollen grains and seasonal consumption of insects and arthropods.[1]

Although natural feeding habits comprise both plant-based and animal-based foods (depending on locale and season), behaviorally and morphologically, gliders should not be considered insectivores. Glider teeth are designed to compress, not shear, insects—to extract the nutrients within hemolymph and soft tissues—and the animals discard the less digestible, hard exoskeleton.[1] The digestive tract comprises a fairly simple small intestine for protein and sugar digestion, with a large cecum for possible microbial fermentation of complex carbohydrates (gums). Sugar gliders have a low basal metabolic rate, requiring only about 46.2 kJ/d for a 130-g animal. With normal activity, these energy expenditures increase to between 84 and 126 kJ/d, and field metabolic rates (high activity, searching) increase to about 4 times the basal metabolic rate.[1] Gliders also have a low nitrogen (protein) requirement, measured in the laboratory at only 87 mg N $kg^{-0.75}$ $d^{-1}$ or about 131-mg crude protein (0.13 g) per day.[1] Lactating females have a requirement up to 4 times higher, and, as with all species, growth and reproduction states require higher protein diets.

The natural diet of wild gliders, primarily plant and insect exudates, is impractical for feeding captive gliders kept as pets. Various formulas for captive diets have been developed, including modification of an artificial nectar/protein mix originally formulated for Leadbeater's possums (*Gymnobelideus leadbeateri*), comprised of water, honey, hard-boiled egg, high-protein baby cereal, and vitamin and mineral supplements.[2] Nutritionally balanced, commercially available products developed originally for other species have also been fed successfully in zoo and private glider colonies.

Despite the current detailed knowledge and the fact that gliders have been kept as pets for a number of years, many companion gliders still present for veterinary care with problems related to improper feeding, including malnutrition, obesity, osteodystrophy, and dental disease.[2] This trial was designed to investigate basic nutritional parameters of some commonly used diets fed to gliders in the United

---

*From the Center for Environmental Research and Conservation, Department of Nutrition, Bronx, NY 10460-1099 USA.*

*Address correspondence to: Dr. Ellen S. Dierenfeld, Center for Environmental Research and Conservation, Department of Nutrition, 2300 Southern Blvd, Bronx, NY 10460-1099. E-mail: esd17@columbia.edu.*

*1557-5063/06/1503-$30.00*
*doi:10.1053/j.jepm.2006.06.008*

States in an effort to better understand nutrient links with health and disease.

## Materials and Methods

Nine young (4- to 9-month-old) male sugar gliders were separately housed in plastic-coated wire cages measuring approximately 76 cm (width) × 46 cm (diameter) × 91 cm (height) (30 in × 18 in × 36 in). The animals were maintained in close visual, audio, and olfactory proximity. Cages contained a nesting pouch, drip water bottle, 3 feeding dishes, exercise wheel, wooden dowels for gnawing and climbing, an artificial vine, a rope toy, and paper towel bedding. In addition, matching small plastic toys were added and removed throughout the study for stimulation and play. Room temperature was maintained between 24 °C and 29°C (75°-85°F) with a 12 hour light cycle. Paper towel bedding was changed daily, and the cages were sprayed and scrubbed weekly with a 10% bleach solution. At the beginning of the study, individuals were anesthetized with isoflurane (Vedco Inc., St. Joseph, MO USA) inhalant anesthesia (3%) with oxygen flow (0.8 to 1.0 L/min). Attempts were made to obtain serum samples for laboratory analysis including clinical chemistry, hematology, mineral panels, and fat-soluble vitamin concentrations. This was repeated after approximately 3 months.

Three gliders were randomly assigned to each of the following diet treatments between August and October 2003: diet A: 15-g Insectivore Fare (Reliable Protein Products, Rancho Mirage, CA USA); diet B: 15-g soaked dry test extrusion (the dry extrusion was soaked in water to improve palatability at a ratio of 1 part dry kibble [Eight in One Pet Products, Happauge, NY USA] to 2 parts water); or diet C: 15-g homemade formulation—Bourbon's Modified Leadbeater's diet (for the most current version of this recipe description, see http://www.sugargliders.org/gliderinfo/diets/bml.htm). Fifteen grams of frozen mixed vegetables (peas, corn, and carrots) and assorted fresh fruit or frozen berries were offered with each treatment. Diet A was supplemented daily with 1 g of a 1:1 mix of RepCal calcium supplement (nonphosphorus with vitamin $D_3$; Rep-Cal Research Labs, Los Gatos, CA USA) and Vionate powder (Gimborn Pet Specialties, LLC, Atlanta, GA USA) added to the fruit. In addition, diet A contained 4 protein supplements per week. One teaspoon 1:1 chopped boiled chicken and Special K (Kellogg's, Battle Creek, MI USA) cereal mix moistened with apple juice was added on 2 days, and 10 mealworms were added on 2 other days. Diet B was supplemented daily with 0.5 g of Frugivore Salad Supplement (HMS Diets, Bluffton, IN USA) on the produce mixture, and 5 mealworms were added 4 times a week. Diet C was supplemented with 5 mealworms added 4 times a week. The gliders were fed daily between 1800 and 2200 hours, and each component (protein, vegetable, and fruit) was offered in a separate dish. Individuals were weighed weekly, with a 10% weight loss requiring removal from the study. Diet ingredients and amounts offered are found in Table 1 (diets A-C).

Intake and digestion were measured during two 5-day periods by weighing all food left over and collected from the cages with dehydration corrections. Dehydration corrections were established from control dishes of each separate component held in the same room. All feces were collected, weighed wet, dried with a dehydrator, and then weighed dry. Dried feces were pooled by individual and stored in labeled plastic bags. During the same 5-day periods, the gliders were individually observed for 1 hour and data on diet intake and behavioral preferences were recorded.

Diet and fecal samples were submitted for proximate (water, protein, fat, and ash content) and mineral nutrient analysis (Dairy One Forage Laboratory, Ithaca, NY USA), and diets were also evaluated with Zootrition software (Saint Louis Zoo, St. Louis, MO USA). Veterinary health checks, including examination of tooth/gum health, parasites, and radiography to evaluate bone density, were conducted on all animals at the beginning and end of the trials, and all animals were weighed weekly. Blood samples were taken and analyzed for blood chemistry (Antech Diagnostics, Tampa, FL USA), hematology, vitamin D (Boston University, Boston, MA USA), and mineral (University of Pennsylvania, New Bolton Center, PA USA) status at the beginning and end of the study as sample size permitted. Because of the small size of the animals and volumes needed for tests, chemistry and mineral assays were performed on all individuals at the start of the trial, but treatment group samples were pooled for vitamin and mineral analyses as response variables measured at the end of the study. One glider treated with diet A was removed from the study because of self-mutilation.

## Results and Discussion

### Feeding Trials

Consumption data are presented in Table 1, with results summarized over both 5-day trial periods. Overall, the animals averaged 96.2 g ± 10.7 g (range, 78-108 g) at the start of the feeding trials, and ate

### Table 1. Average Daily Amounts Offered to and Consumed by Sugar Gliders (*Petaurus breviceps*; n = 3 Animals per Treatment) in Feeding Trials Conducted September to October 2003

| Ingredient | Amount offered (g) | Amount eaten (g) | % Consumed |
|---|---|---|---|
| **Diet A** | | | |
| Insectivore Fare | 15 | 6 | 41 |
| Mixed vegetables (peas, corn, carrots) | 15 | 7 | 41 |
| Assorted fresh fruits and berries | 15 | 12 | 76 |
| 1:1 mix supplements (RepCal and Vionate) | 1 | 1 | 100 |
| Protein 4X/wk (6 g chicken/Special K cereal mix or 1 g mealworms - each 2 d/wk) | 1.8 | 1.8 | 100 |
| **Diet B** | | | |
| Soaked dry kibble | 15 | 14 | 95 |
| Mixed vegetables (peas, corn, carrots) | 15 | 8 | 51 |
| Assorted fresh fruits and berries | 15 | 14 | 97 |
| Frugivore Salad Supplement | 0.5 | 0.5 | 100 |
| Mealworms | 0.4 | 0.3 | 75 |
| **Diet C** | | | |
| Homemade formulation (Bourbon's Modified Leadbeater's Diet) | 15 | 13 | 89 |
| Mixed vegetables (peas, corn, carrots) | 15 | 6 | 38 |
| Assorted fresh fruits and berries | 15 | 12 | 77 |
| Mealworms | 0.3 | 0.3 | 100 |

26 g to 37 g of wet food daily (about 30% to 40% of the body weight) over the 2 feeding trial periods. All diets contained approximately 70% to 80% water; hence, dry matter consumption (water removed) amounted to ~7% to 8.5% of the weight of each individual glider. Animals showed preferences to different food types. In this study, the meats (chicken and mealworms) and fruit mixes were preferred; the majority of those ingredients offered were eaten (75%-100%). As for the basal diet, the soaked kibble diet (diet B) appeared to be consumed to the greatest extent (95%), followed by diet C (the homemade formulation, 89% consumed), and lastly, Insectivore Fare (diet A; 41% consumed). Vegetables were the least preferred, with 38% to 51% of vegetables offered consumed.

Animals were all weighed on the same scale (Ohaus CS-200; ± 1 g; Ohaus Corporation, Pine Brook, NJ USA) at the beginning and end of the test period. Group weights did not vary throughout the trial (see Table 2) because of individual variability, although animals on diet A averaged about 10 g smaller than the other 2 groups and may have comprised slightly younger animals. All animals were growing during the study period, but none were in the most rapid growth phase. Two of 3 gliders consuming diet C lost weight, whereas the third animal fed diet C displayed the greatest gain of all individuals throughout the trial (+12 g). Diet A animals gained an average of 8.2% body weight (107 mg/d), diet B, 2.3% (35 mg/d), and diet C gliders, 2.0% (30 mg/d) over the trial period.

Nutrient composition for the various diets is reported in Table 3. Dry matter digestibility was high-

### Table 2. Average Body Weights of Young Male Sugar Gliders (*Petaurus breviceps*; n = 3 Per Treatment) Fed Different Diets in a 2-Month Feeding Trial

| Diet treatment | Pretrial body weight (g) | Posttrial body weight (g) |
|---|---|---|
| A | 87.3 ± 10.1 | 94.5 ± 16.3 |
| B | 102.3 ± 0.6 | 104.7 ± 3.2 |
| C | 99.0 ± 13.1 | 101.0 ± 17.1 |

est for diet C, at 78.5%; diet A was 73.4% digestible; and diet B, 76.9% digestible. As with all animals, energy drives appetite. Based on standard equations used for marsupials[1] and with normal activity and growth estimated at 3 times the basal metabolic rate, these 100-g gliders required ~109.2 kJ per day. Diet A, as offered, supplied 231 kJ; only 117.6 kJ were consumed because of the selective feeding behavior. Diet B supplied 151.2 kJ; 147 kJ were eaten. Diet C supplied 138.6 kJ daily; 100.8 kJ were consumed. All diets supplied more energy than needed by the animals, thus allowing selective feeding behaviors. Given excess, gliders ate preferred items, which resulted in diets consumed that differed in nutrient composition from diets offered (see Table 3). Diet A was most effectively used by gliders, because it was consumed and digested to the lowest degree, yet resulted in the greatest weight gain.

**Table 3. Chemical Composition (Nutrients on a Dry Matter Basis) of Diets Offered to and Eaten by Sugar Gliders (*Petaurus breviceps*; n = 3 Animals per Treatment) in Feeding Trials Conducted September to October 2003**

| Diet | % Protein | % Fat | % Ca | % P |
|---|---|---|---|---|
| A | | | | |
| Offered | 25.6 | 6.6 | 1.3 | 0.2 |
| Eaten | 23.5 | 5.6 | 2.0 | 0.2 |
| B | | | | |
| Offered | 25.9 | 13.8 | 0.7 | 0.7 |
| Eaten | 25.6 | 13.5 | 0.7 | 0.7 |
| C | | | | |
| Offered | 18.6 | 7.6 | 2.9 | 0.4 |
| Eaten | 19.0 | 8.8 | 3.5 | 0.5 |

Analytically, total diets varied in nutrient content, ranging in protein from ~19% to 26% dry matter, and fats from 6% to 14% dry matter (Table 3). Fruits and vegetables, gums, and nectars alone cannot supply the levels of protein or fat as consumed during this trial, hence the basal diet becomes critical in meeting the nutrient requirements for sugar gliders. Similar to a baby "filling up" on fruit juice, if a glider is fed a diet comprised solely of fruits and vegetables, it may meet energy (or calorie) needs, but is unlikely to meet requirements for other nutrients, including protein. If a high fat diet is consumed, the animal may likewise meet energy needs before other nutrient requirements are met.

In general, protein (nitrogen) requirements for sugar gliders are not high. Published diet trials with 1.0%, 3.1%, and 6.5% protein (dry basis) determined glider requirements for a 100-g animal at only 248-mg crude protein.[4] By comparison, diets in this trial provided: diet A: 1920-mg protein, diet B: 2270-mg protein, and diet C: 1330-mg protein. All diets in this study provided more than adequate levels of protein by comparison with stated needs. In addition, we were able to estimate protein digestibility on all 3 diets, ranging from 67% (diets A and C) to 70% (diet B). However, amino acids were not measured in this study, and diets varied in ingredients, which explain protein quality. Gliders may have consumed excess protein to meet specific amino acid requirements, but further detailed investigations would need to be conducted for that determination. The apparent increase in blood urea nitrogen concentration (Table 4) may be an artifact of small sample size (2 individuals) and/or indicative of tissue catabolism rather than a reflection of diet, per se. Interestingly, animals on diet A (pretrial samples available only) displayed values within the Australian zoo reference range; the diet B sample post-feeding was at the high end of the range (24 mg/dL), whereas the diet C sample was high (39 mg/dL). A difference between United States and Australian zoo dietary protein content and quality may underlie the range variability, but this remains to be investigated.

Calcium (Ca) deficiencies can lead to tetany and have been reported in gliders.[2] These deficiencies have been linked with diets high in fruits and insects, preferred food items that can be poor sources of calcium, and hence the need for supplementing this mineral. However, one must be careful in supplying Ca to maintain nutrient balance. The optimal ratio of Ca and phosphorus (P) is 1:1 to 2:1, at least as much Ca as P and, optimally, twice as much Ca as P. In these diets, only diet B (soaked kibble diet) contained the optimal Ca:P ratio, and it was marginally optimal at 1:1. Diet A, as prepared, contained 6.5 times more Ca than P and, as eaten, 10 times more Ca than P. Similarly, diet C contained 7 to 8 times more Ca than P. Although absolute Ca requirements of sugar gliders are unknown, based on other animals, a value between 0.5% and 1% of dry matter is anticipated for this species, with a dietary P requirement between 0.2% and 0.5%.[3] Diet B appears too high in P relative to Ca, whereas diets A and C both appear too low. Bone density checks through radiographic examination would be one means of evaluating whether these diets may have affected bone quality though imbalanced Ca:P ratios. Radiographs appeared normal in all gliders during the course of this investigation.

**Table 4. Clinical Chemistry Values from Young Sugar Gliders in a Controlled Feeding Trial**

| Component | Pretrial (n = 9; diet A) | Posttrial (n = 1; diet B) | US zoo references* | Australian zoo references* | Reference values† |
|---|---|---|---|---|---|
| Glucose (mg/dL) | 96.3 ± 31.2 | 51.0 | 154 ± 78 | 5–124 | 130–183 |
| Blood urea nitrogen (mg/dL) | 15.3 ± 0.6 | 31.5 ± 10.6<br>(n = 2; diets B and C) | 33 ± 56 | 10–27 | 18–24 |
| Creatinine (mg/dL) | 0.4 ± 0.3 | 0.3 | 0.7 ± 0.1 | 0.2–1.5 | 0.3–0.5 |
| Alkaline phosphatase (U/L) | 136.2 ± 35.0 | 129 | 183 ± 30 | 188 | |
| Cholesterol (mg/dL) | 106.7 ± 16.7 | 135 | 161 ± 2 | 128–248 | |
| Globulin (g/dL) | 2.5 ± 0.9 | 1.2 | 1.7 ± 0.2 | 0.6–3.0 | |
| Creatine phosphokinase (U/L) | 524 ± 259.6 | 558 | 503 ± 48 | 224 | 210–589 |

**Reference data from: Pye and Carpenter, 1999.*
*†Reference data from: Ness and Booth, 2004.*

Because of limitations of sample size, and the fact that bone problems have been reported in sugar gliders that are likely associated with low vitamin D and/or Ca and P levels, the only fat-soluble vitamin concentration measured in this study was 25-hydroxyvitamin D. To our knowledge, this is the first time these values have been reported in this species; gliders fed diet A displayed a circulating level of 53 ng/mL; those fed diet B, 70 ng/mL; and those fed diet C, 18 ng/mL (individuals pooled per treatment group).

To our knowledge, there is no 25-hydroxyvitamin D reference for this species; however, in this study animals fed diet B, the soaked kibble extrusion, had much higher levels than those fed the homemade diet formulation (diet C). Both diets A and C were supplemented with RepCal, containing vitamin D, to supply this nutrient, and calculated analyses suggest that vitamin D levels in those diets were quite elevated (diet A, 28 IU/g; diet C, 34 IU/g) compared with the concentration in diet B, 1.3 IU/g (all on a dry matter basis). Although we do not know the requirement for this nutrient in sugar gliders (and it may be quite low because of the fact that they would not naturally consume high quantities and are nocturnal, so they may be independent of it even from sun exposure), it is possible that diets containing high levels of vitamin D may produce a feedback mechanism to actually decrease circulating concentrations. For many other species, including sugar gliders,[3] dietary vitamin D levels are recommended between 0.5 IU/g and 1.5 IU/g of dry matter, the level that diet B contained. Radiographs on the study gliders did not suggest poor bone density nor were soft tissue mineralizations noted that might indicate vitamin D toxicosis. Nonetheless, vitamin D metabolism needs to be investigated in more detail in this species.

## Health Assessment

The small size of these animals limited the size of samples and individual data points we were able to collect on each animal, which necessitated pooled diet treatments and provided a lack of statistical evaluation. Hematology parameters (data not shown) from the prefeeding trial samples were within ranges previously reported as acceptable for sugar gliders, with a pooled hematocrit of 46.6% compared with reported values between 45% and 53%,[2] and 43% (gliders in US zoos) and 48% (gliders in Australian zoos).[5] Similarly, the white blood cell count of 8.4 × $10^3$ cell/$\mu$l was within reported ranges for captive gliders (5.3-16.3 × $10^3$ cell/$\mu$l[5]; 5.0-12.2 × $10^3$ cell/$\mu$l[2]). No obvious or consistent abnormalities were evident in blood chemistries (Table 4), and gliders in the study were considered to be healthy.

## Mineral Data

Mineral levels were measured in blood samples collected during prefeeding and postfeeding trials to obtain more complete information on circulating concentrations, but again were relegated to using pooled samples. Trace elements (components of toxicology panels) are found in Table 5, and more

**Table 5. Sugar Gliders Pretrial and Posttrial**

| Component | Pretrial (n = 1 pooled sample) | Posttrial (n = 3) |
|---|---|---|
| As | 0.16 | 0.13 ± 0.02 |
| Cd | <0.01 | <0.01 |
| Co | 0.06 | 0.1 ± 0.09 |
| Mo | 0.09 | 0.06 ± 0.01 |
| Pb | <0.05 | <0.05 |
| Se | 0.32 | Not analyzed |

*Post-trial samples pooled by dietary treatment for analysis.*

typical mineral data for assessment of nutritional status are found in Table 6. We had adequate samples from each individual for a mineral panel prefeeding trial; however, we were only able to obtain 3 pooled treatment samples for analysis postfeeding, hence statistical evaluation was not possible.

Although, again, specific data do not exist for gliders, based on comparison with other species, all trace element data appear to be within expected ranges. Macromineral data, however, suggest some issues that may be of concern from a health perspective. Copper and sodium values are similar to those expected for other species and did not vary over the trial period. Clearly, the fact that we were unable to measure each individual postfeeding trial limits interpretation of these limited data. Pretrial values for Ca and magnesium were, however, elevated for all individuals. This may be possibly due to excess dietary supplementation before the gliders' acquisition for the study, and/or possible contaminants incorporated into supplements; all animals had been maintained on diet A before the trials. Similarly, supplement contamination may underlie the very elevated iron levels determined from blood samples taken both prefeeding (hemolyzed) and postfeeding trial. The posttrial samples were not hemolyzed, yet they were still high, possibly indicating excess dietary iron levels. Iron is a very common contaminant of calcium supplements and can be seriously toxic at high levels, leading to iron storage disease and liver damage.[6]

Iron storage disease has been described in captive frugivorous birds, bats, and primates, often as a secondary finding at necropsy. Although it has not previously been reported in sugar gliders, evidence of excess tissue iron has been seen in sugar gliders at necropsy (Thomas, unpublished personal communication, 2003; necropsies performed at Great Neck Veterinary Clinic, Virginia, VA USA, and biopsy tissues submitted in formalin reported by Tammy Johnson, DVM, ACVP). Dietary excesses of iron (both from supplements as well as from animal-based foods [heme versus nonheme iron]) can contribute to this syndrome, along with high levels of dietary vitamin C, which directly increase iron absorption.[6] In this trial, we also recorded elevated iron in the feces of all sugar gliders (data not reported here), and so we suspect dietary iron overload.

Although actual dietary requirements for iron and vitamin C in sugar gliders are unknown at this time, we estimate that dietary iron concentrations should be less than 50 μg/g dry diet, and vitamin C should be 100 mg/kg. By calculation, all diet treatments in this study appeared to supply more iron and vitamin C than may be needed by sugar gliders (87 mg/kg, 175 mg/kg, and 292 mg/kg iron, and 212 mg/kg. 222 mg/kg, and 260 mg/kg vitamin C for diets A, B, and C, respectively), which may contribute to the observations noted. Transferrin and ferritin saturation parameters are much better indicators of iron overload than simply circulating total iron in blood samples, and tissue biopsies and histology are needed to confirm a problem. However, inferential evidence suggests that occurrence of iron overload may be worth investigating in more detail in this species.

## Conclusions

None of the 3 diets tested appear to contain the optimal balance for meeting the nutritional needs of sugar gliders, but the information obtained does provide further insight into the dietary requirements of these animals. We did find that:

**Table 6. Sugar Gliders Pretrial and Posttrial**

| Component | Pretrial (n = 9) | Post-Trial (n = 3) |
|---|---|---|
| Calcium | 110.2 ± 13.8 | 87.4 ± 0.31 |
| Copper | 0.57 ± 0.12 | 0.43 ± 0.04 |
| Iron | 18.8* ± 12.9 | 8.4 ± 3.91 |
| Potassium | 534.9 ± 98.1 (n = 3) | 600 (n = 1) |
| Magnesium | 44.4 ± 6.7 | 26.1 ± 2.48 |
| Sodium | 3749 (n = 1) | 3523 ± 220 |
| Phosphorus | 323.9 ± 86.8* | 202.7 ± 9.5 |
| Zinc | 2.7 ± 1.4 | 4.1 ± 1.2 |

*Post-trial samples pooled by dietary treatment for analysis*
**Hemolyzed samples.*

1) Young, healthy male gliders appear to require between 105 kJ/d and 147 kJ/d—not a lot of calories;

2) Total protein (as nitrogen) was apparently not limiting in any of the diets, but quality may have been marginal, particularly in diet C (evidenced by weight loss);

3) Diets currently being fed to captive sugar gliders are highly digestible; however, additional comparisons to determine digestibility of natural diets, especially gums, to target optimal nutrient levels are required; and

4) Evidence of mineral and vitamin imbalances in commonly fed diets, especially vitamin D and iron, which may be impacting health and need to be investigated further.

Good science identifies more questions than it answers; although some of these ideas have been previously presented, the data from this trial suggest that more concentrated efforts need to be made to look at vitamin D, Ca, and P metabolism and interactions in sugar gliders, because osteodystrophy and calcium tetany can still be problematic.

We need to identify whether gliders have the enzyme for making their own vitamin C as do many animals. If so, excess dietary supplementation may not be warranted and may actually contribute to iron overload. On that note, blood carrier and storage proteins for iron should also be investigated—saturation of transferrin and ferritin—in this species.

We still need to know the effects of gums on the gut health of sugar gliders. Gliders have a huge cecum for fermenting soluble fiber, and we are really not giving them much opportunity to do so with current feeding practices. The effects of different simple and complex sugars on gut health, microbiology, and overall physiology need to be investigated in more detail.

## Acknowledgments

We appreciate the financial support of the Glider Research Fund for funding the trial and analyses, as well as those who donated time, ideas, encouragement, and diet. Animals used in the trial were kindly loaned and shipped by Sun Coast Sugar Gliders, and, for this, we sincerely thank Lisa Bordelon. Dr. Andrea Fidgett assisted with diet summaries. Efforts from Tom Havens, Ellen Ross, and Claudia Obrock in initiating this study are gratefully acknowledged.

## References

1. Hume ID: Marsupial Nutrition. Cambridge, UK, Cambridge University Press, 1999
2. Ness RD, Booth R: Sugar gliders, in Quesenberrry KE, Carpenter JW (eds): Ferrets, Rabbits, and Rodents Clinical Medicine and Surgery (ed 2). St. Louis, MO, Elsevier Inc, 2004, pp 330-338
3. Booth RJ: General husbandry and medical care of sugar gliders, in Bonagura JD (ed): Kirk's Current Veterinary Therapy XIII. Philadelphia, PA, WB Saunders, 2000, pp 1157-1163
4. Smith AP, Green SW: Nitrogen requirements of the sugarglider (*Petaurus breviceps*), an omnivorous marsupial, on a honey-pollen diet. Physiol Zool 60:82-92, 1987
5. Pye GW, Carpenter JW: A guide to medicine and surgery in sugar gliders. Vet Med 94:891-905, 1999
6. Sheppard C, Dierenfeld ES: Iron storage disease in birds: speculations on etiology, implications for captive husbandry. J Avian Med Surg 16:192-197, 2002