The Nutrition of the Budgerigar (*Melopsittacus undulatus*)[1]

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ABSTRACT Growing interest in the nutrition of the budgerigar (*Melopsittacus undulatus*) has highlighted the paucity of knowledge in this area. The aims of this study were to review the available literature on their individual nutrient requirements and relate this to the nutrient content of their predominantly seed-based diet and to investigate the effect of the bird's daily energy requirement on the fluctuations in body weight. Studies were conducted at the Waltham Centre to measure the relationship between daily metabolizable energy intake (kJ/kg BW) and body weight change (g/d) for groups of adult budgerigars. The birds were found to require daily 48–128 kJ/bird depending on their body mass (birds in our colony typically weigh 30–80 g). During a series of breeding trials the daily energy intake for a breeding pair plus their three chicks, at peak energy intake, was found to be 483–505 kJ (at pairing, the mean daily energy intake of the breeding pairs was 231 kJ). Apparent metabolizability of the major nutrients from a seed diet were generally found to be >80%, which allows these birds to assimilate the high levels of energy needed for their basal metabolism. In summary, the nutrient requirements of the budgerigar (where known) were found to be similar to those of other avian species, however, further work is needed, especially in the area of availability of key nutrients. Further developments in the dietary management of these birds will only be possible if researchers can overcome the birds' poor acceptance of novel foods and satisfy their high basal energy requirements before establishing their requirements for individual nutrients. J. Nutr. 121: S186–S192, 1991.

INDEXING KEY WORDS:

• *symposium* • *birds* • *budgerigar* • *Melopsittacus undulatus* • *avian nutrition*

The budgerigar (*Melopsittacus undulatus*) is a member of the parrot family that is widely kept throughout Europe and North America as a domestic pet. Originally native to Australia these small psittacine birds are known to live in flocks and eat mainly seeds of ground vegetation (1). The emergence of intensive breeding programs among budgerigar fanciers has led to an increased level of awareness of the role of nutrition in the maintenance of a healthy flock. Budgerigar owners expect their birds to live a long, healthy life and therefore require a greater understanding of correct dietary management to achieve this. Although the recommended daily allowances of individual nutrients for feeding healthy budgerigars have yet to be documented, data have often been extrapolated from other avian species such as the chicken. There has been extensive research into the nutritional requirements of the production birds and in 1984 the National Research Council published the eighth edition of *The Nutrient Requirements of Poultry*, which collated all available research data (2). It will therefore be appropriate, where possible, to relate the nutrient content and the energy density of diets for budgerigars to that of other avian species.

The science of nutrition encompasses a variety of factors that are interlinked and should not be considered in isolation. These include the nutrient content, energy content, digestibility and palatability of a particular food. The nutrient requirements are also affected by the physiological state of the animal and factors such as age, breeding, moulting, and the general health of the bird may result in an increased demand for certain key nutrients. For example, dietary protein has an important role in the diet of captive psittacine birds especially in the production of feathers, claws and beak. The protein requirement of the budgerigar has been estimated to be 10% of the diet (3), and this requirement could well increase by a factor of two or three during moulting.

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Table 1 shows a list of seeds commonly fed to budgerigars and their major nutrient concentration.[3] The nutrient concentrations of these seeds are very similar. However, there may be an advantage in selecting more canary seed and groats (hulled oats) at times of high protein demand, i.e., moulting or the formation of crop milk by the hen. Any excess protein from the diet will be utilized as energy by the bird or metabolized to uric acid and excreted. The data establishing the requirements for individual amino acids in the adult budgerigar are somewhat sparse; however, one study gave figures of 2.0, 3.5 and 3.5% for lysine, arginine and methionine plus cysteine, as a percent of the total crude protein (3). **Table 2** shows the amino acid profile of these seeds, all of them adequately supply the maintenance requirement of this bird; 2.0–3.9, 3.0–7.8 and 4.0–5.2% of the total crude protein, respectively. The main biological function of fat is to provide a source of essential fatty acids and to be oxidized for energy. The budgerigars benefit from ingesting seeds of high fat content to support their high metabolic rate. Fat also acts as a carrier medium for the fat-soluble vitamins. For other domestic avian species, the daily requirement for linoleic acid is 1% of the diet (2). Levels of linoleic acid in seeds often fed to budgerigars are sufficiently high so that it is unlikely that a budgerigar would have a diet deficient in linoleic acid. There is a wide variation in the total fat content of these seeds, (Table 1 acid-ether extract). Groats and canary seed contain slightly higher levels of fat than millet. As most birds are prone to obesity it may be prudent to provide only a small quantity of the higher fat content seeds in the budgerigar's diet.

[3] Seed and excreta samples were analyzed for gross energy (Gallenkamp Autobomb, Sussex, UK), total nitrogen (Kjeldahl method using a Kjel Foro automated analyser, Foss Electric, Denmark), fat (11), ash (samples heated at 550°C for 5 h) and moisture (samples dried at 105°C for 5 h.

TABLE 1

Nutrient analysis of seed kernels commonly fed to budgerigars[1]

	Crude protein	Acid-ether extract	Linoleic acid	NFE[2]
	g/kg kernel, fresh weight			
White millet	115.0 ± 4.0	35.0 ± 8.0	24.0 ± 2.0	712.0 ± 25.0
Red millet	116.0 ± 11.0	38.0 ± 4.0	21.0 ± 3.0	699.0 ± 10.0
Canary	156.0 ± 31.0	56.0 ± 5.0	23.0 ± 2.0	615.0 ± 58.0
Groats[3]	135.0 ± 18.0	66.0 ± 5.0	17.0 ± 1.0	707.0 ± 45.0

[1] Values are means ± SD; $n = 3$.
[2] NFE = nitrogen-free extract, calculated by difference; ash was determined but not reported.
[3] Hulled oats.

TABLE 2

Measured amino acid concentration of the kernels of seeds commonly fed to budgerigars

	White millet	Red millet	Canary	Groats[1]
	g/kg kernel, fresh weight			
Protein	115.0	116.0	156.0	135.5
Arginine	3.4	3.8	10.2	9.5
Glycine + serine	10.0	11.4	13.9	11.6
Histidine	2.4	3.0	3.4	2.9
Isoleucine	2.9	4.6	3.9	4.0
Leucine	12.9	14.6	11.6	7.9
Lysine	2.1	2.7	5.0	4.8
Methionine + cystine	5.0	5.5	7.7	6.3
Methionine	3.1	2.1	2.8	2.1
Phenylalanine + tyrosine	21.5	27.5	20.3	32.2
Phenylalanine	17.9	22.8	17.3	17.9
Threonine	3.1	4.6	4.2	4.1
Tryptophan	0.16	0.16	0.50	0.16
Valine	3.9	5.7	5.2	5.2

[1] Hulled oats.

The primary energy source for seed eating birds is carbohydrate, mostly in the form of starch that is present in the endosperm of the seed. The fiber content of the seed in not digested by the psittacine birds. The budgerigar hulls the seeds, therefore discarding the less-digestible material. It is unlikely that these birds would have a nutritional deficiency associated with carbohydrate as most seeds contain very high levels of this nutrient (Table 1 NFE). As in all animal species, vitamins are required in small but finite amounts in the diet to facilitate many of the chemical reactions involved in bodily function. There are a number of complex nutrient interactions that may ultimately lead to imbalances in vitamin metabolism, for example, nutritional muscular dystrophy in the chicken is exacerbated by a deficiency of the sulfur amino acids and/or selenium deficiency (5, 6). It is therefore inappropriate to assess nutrients in isolation; they must be put into context with the entire composition of the bird's diet.

Vitamin A is a frequently over-supplemented component of a budgerigars' diet because of the lack of information available on their requirement for this vitamin. Vitamin A is a fat-soluble vitamin which can be formed from the vegetable pigment β-carotene, but is also available in cod-liver oil (165,000 μg/L), which is frequently used by budgerigar breeders as a dietary supplement (6). Seeds contain no vitamin A and are generally poor sources of β-carotene. It is not uncommon to find budgerigars with clinical signs of vitamin A deficiency if the diet has not been adequately supplemented. However, over-supplementation can be just as harmful, as this can lead to hypervitaminosis A, which in extreme cases can be lethal. Information

TABLE 3

Concentration of total carotene in whole seeds commonly fed to budgerigars

	Total carotene
	mg/kg seed, fresh weight
White millet	1.8
Red millet	3.4
Canary	0.33
Groats[1]	6.2

[1] Hulled oats.

is available on the vitamin A requirement of other domestic avian species that suggests that they need 1200 μg/kg of the diet (2), and recent work carried out by Baker (7) indicated that only 12 μg/bird would be needed daily by the budgerigar with a maximum tolerance limit of 750 μg/bird. It is therefore important that vitamin supplements (especially those containing fat-soluble vitamins) are not used indiscriminantly for addition to a budgerigars' diet. Ideally the budgerigar's diet should be supplemented to supply a minimum daily intake of 12 μg; this can be achieved either by using a balanced, prepared diet i.e., TRILL[4] (3600 μg/kg as retinyl acetate: 30–60 μg/bird) or by adding 7.5 mL of cod-liver oil to each kilogram mixture of seeds (1260 μg/kg: 12–21 μg/bird). Plant carotenes are known to be dietary precursors to vitamin A, and seeds contain a total carotene concentration of <10 mg/kg (**Table 3**). It was not possible to assess the adequacy of these levels of carotene as it is not yet known what proportion of the carotene content of the seeds the psittacine birds can convert to vitamin A. However, it is not uncommon to observe hypovitaminosis A in psittacine birds fed restricted diets of single, unsupplemented seeds (8, 9).

Minerals are the fifth group of nutrients needed by the budgerigar and have functions related to structure of the skeleton, maintenance of body pH and water balance. Interactions occur between various minerals, for example, calcium and zinc or calcium and phosphorus; therefore, excessive concentrations of one mineral in the food may lead to dietary imbalance. The correct concentration of calcium in the diet of the growing budgerigar is crucial to skeletal development and neuromuscular function. The calcium requirements of many domesticated growing birds have been calculated to be 0.6–1.0% of their diet (2). However, this requirement will also be dependent on many factors such as the dietary phosphorus concentration, their growth rate and egg production. Phosphorus, from seed sources, is mainly in the form of hexainositol phosphate (phytate) and is not readily available to the bird. **Table 4** shows the concentration of available phosphorus in seeds. Additionally, the inositol phosphate may bind zinc, iron and manganese to render them unavailable. Table 4 shows the concentration of calcium and phosphorus in a selection of seeds commonly fed to budgerigars; the calcium concentration of all these seeds is insufficient if one assumes the requirement to be similar to other avian species (0.6–1.0% of the diet). However, budgerigars may obtain calcium from other sources such as cuttle fish blocks and oyster shell grit, the quantities of which are difficult to assess. The total phosphorus content of these seeds is an overestimate of the biologically available phosphorus, and therefore the situation may not be quite as harmful as the analytical data would lead us to believe. Many commercially available seed mixtures are supplemented with calcium and so it is unlikely that skeletal abnormalities will develop. Discussion of the calcium requirement of the budgerigar would not be complete without mentioning vitamin D. Vitamin D is essential for regulation of calcium absorption from the digestive tract and deposition/resorption of calcium from bone. Vitamin D is chemically modified in the liver to 25-hydroxycholecalciferol and in the kidney to 1,25-dihydroxycholecalciferol, which are the most metabolically active forms of this vitamin. Growing birds deficient in vitamin D will develop rickets, and feathering may also be affected. Domesticated laying birds fed a deficient diet will produce eggs with increasingly thin shells and egg production will also decline (10). Birds exposed to sunlight will synthesize adequate amounts of vitamin D from sterols present in their skin. Alternatively, the diet must be supplemented, and cod-liver oil is often used to provide this vitamin (1.9 g/L). Baker (7) suggested a daily requirement of 0.25 mg/bird for the budgerigar, which is equivalent to adding <1 mL of cod-liver oil to each kilogram of seed, if the birds do not have access to direct sunlight.

Finally, it would be inappropriate to discuss the nutrient content of a budgerigar's diet without discussing the need for water. Water requirements are affected

TABLE 4

Calcium and phosphorus concentration of seed kernels commonly fed to budgerigars

	Ca	Total P	Phytate	Available P	Ca:avail P
	g/kg kernel fresh weight				
White millet	0.15	2.6	2.6	0.10	1.5
Red millet	0.13	2.5	2.1	0.40	0.33
Canary	0.41	4.1	3.0	1.10	0.37
Groats[1]	0.44	3.4	2.3	1.10	0.40

[1] Hulled oats.

[4] Produced by Pedigree Pet Foods, Melton Mowbray, Leicestershire, England.

TABLE 5

Water balance figures for adult budgerigars fed a single seed diet

	Metabolic water	Water drunk	Excreted water	Difference[1]
	g/d			
White millet[2]	3.44 ± 0.23[3]	3.45 ± 0.51	0.28 ± 0.05	+6.61
Canary[4]	3.68 ± 0.40	3.82 ± 0.24	0.33 ± 0.07	+7.17

[1] These figures do not take into account evaporative water loss from the respiratory tract, which was not measured.
[2] Nutrient analysis: protein 11.5%, fat 4.1%, nitrogen free extract 69.4%. Mean daily food intake, 7.3 g.
[3] Value are means ± SD for $n = 12$ birds.
[4] Nutrient analysis: protein 10.8%, fat 3.4%, nitrogen free extract 69.2%. Mean daily food intake, 8.0 g.

TABLE 6

Gross energy concentration of seeds measured by adiabatic bomb calorimetry

	Whole seed	Husk	Kernel[1]
	MJ/kg, fresh weight		
Canary	14.2 ± 1.3	14.7 ± 1.1	14.0 ± 0.9
White millet	16.5 ± 1.1	14.5 ± 1.4	16.7 ± 1.2
Red millet	15.3 ± 1.7	14.5 ± 0.5	15.5 ± 1.1
Mixture[3]	17.0 ± 0.9	14.9 ± 0.9	17.4 ± 0.9

[1] Content of each seed present as kernel: canary, 222.0 ± 30.0 g/kg; white millet, 228 ± 12.0 g/kg; red millet 210 ± 61.0 g/kg; mixture, 166 ± 17.0 g/kg.
[2] Value is mean ± SD for $n = 3$ samples.
[3] TRILL, a commercial mixture of canary seed, white and red millet.

by environmental conditions (temperature, humidity), type of diet (dry or soaked seeds) and physiological state (rate of egg production). The budgerigars in our aviary at the Waltham Centre consume daily an average of 3–5 mL/bird when fed a standard seed diet but consumption increases during breeding. Water also serves a function as a carrier for trace minerals, which are an essential part of the diet. The mineral composition of the water however depends on its source. Water is not only available to the bird from the liquid it drinks but also water from the food it eats and as metabolic water. The water intake will be balanced by water in excreta and water lost through the lungs and during the formation of crop milk in the hen. Birds are very efficient at retaining water and release very little in their excreta; moisture content of the wet excreta was found to be 32.8 ± 6.5% (SD) or 0.25–0.40 mL/d. **Table 5** shows the daily water balance figures for 12 budgerigars fed solus diets of white millet or canary seed. The respiratory water loss will inevitably account for a large proportion of the overall water turnover, however, this loss was not measured.

The energy density of the bird's diet is of key importance to the overall dietary regimen as its food intake is only 8–12 g/d. The birds in the Waltham aviary have, for limited periods, increased their daily food intake to 20 g/bird but after a few days food intake decreased and the birds lost body weight. Investigations were begun to assess the bird's energy requirement, these studies were initially difficult because there were only a limited number of single seeds the budgerigars were willing to eat. Principal seeds used in these investigations were canary, white millet, red millet and combinations of the three. **Table 6** shows the gross energy content of the whole seeds, kernels and husks. The energy of the seed kernel was calculated as a measure of the food energy available for digestion.

A series of feeding studies were carried out with a panel of six cages each containing four adult budgerigars. All birds were given ad libitum access to the test food, water and oyster shell grit. Food intake was measured daily and the budgerigars were weighed every 2 d to ensure weight loss or gain did not exceed 10% of their starting weight. The birds were prefed the test diet for 4 d before excreta collection began; excreta was collected for the group of four birds over a period of 10 d with seed husks and feathers removed manually several times a day from the base of the cage. All food and excreta were assessed for gross energy content by bomb calorimetry to calculate daily metabolizable energy intake.

Figure 1 shows the relationship between daily metabolizable energy intake (MJ/kg BW) and daily body weight change (g) for a total of 11 trials. There was a positive correlation between daily metabolizable energy intake (X, MJ/kg BW) and body weight change

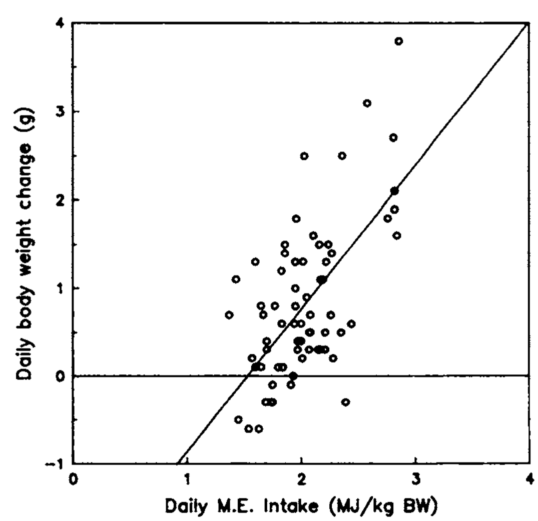

FIGURE 1 Relationship between daily metabolizable energy intake (MJ/kg BW) and the body weight change (g) for the adult budgerigar.

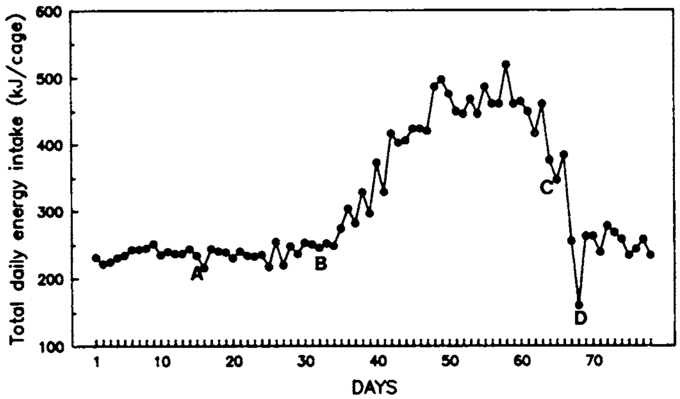

FIGURE 2 Mean daily energy intake (kJ/cage) for breeding pairs of budgerigars throughout the 78-d breeding period.

(Y, g), Y = 0.006 X − 2.28 (r = 0.62, P < 0.001, n = 63). At the point where body weight change was zero, i.e., weight maintenance, the metabolizable energy intake was 1.59 MJ/kg BW. In our colony at the Waltham Centre where the budgerigars weigh 30–80 g this equates to a daily energy requirement of 47.9–127.7 kJ/bird. By plotting the logarithms of the two variables (data were limited to gain or loss of 1 g/d), it was possible to calculate an allometric equation for the relationship between the budgerigar's metabolizable energy intake (Y, MJ/kg BW) and body weight (W, kg); $Y = 104.3\ W^{-0.96}$ (n = 44, r = 0.52, P < 0.001). For a 53-g budgerigar (mean weight of the birds in the Waltham colony) the metabolizable energy intake was calculated as 1.77 MJ/kg BW or 93.8 kJ/bird/daily. An earlier study using adult budgerigars fed a diet based on cellulose powder and soybean oil produced an estimated daily energy requirement of 80–90 kJ/bird (3). Both methods of data analysis gave very similar results for the budgerigar's energy requirements.

An alternative method for calculating the daily metabolizable energy requirement of the budgerigar would be the use of the NRC 1984 equation based on work with chickens (2): daily metabolizable energy/hen = $W^{0.75}$ (173 − 1.95T) + 5.5 ΔW + 2.07 EE, where W = body weight (kg) T = ambient temperature (°C), ΔW = body weight change (g/d) and EE = egg mass (g). By this method the daily energy requirement of the adult budgerigar was found to be 62.2 kJ/bird (mean body weight = 53 g; ambient temperature = 20°C; daily egg mass = 0 g). The daily energy requirement of the adult budgerigar (1.59 MJ/kg BW) was considerably higher than for a chicken, 0.55 MJ/kg BW (2), and would reflect the higher metabolic rate of the budgerigar compared with the chicken.

The energy requirements of the budgerigars during the period of breeding were somewhat more difficult to assess as any disruption of the breeding pairs can lead to destruction of the eggs. **Figure 2** shows the total daily energy intake (kJ/cage) for breeding pairs during the 78-d breeding period from pairing until all the chicks were fledged. All birds were fed ad libitum quantities of a commercial seed mixture (TRILL), which is a supplemented mixture of canary seed, white and red millet, throughout the trial period. At pairing (n = 52) the mean daily energy intake of the adult pairs was 231 kJ/cage with a mean body weight of 55.5 g for cocks and 49.5 g for hens. At point A in Figure 2, the first eggs were laid and at point B the first egg had hatched. Of the 28 pairs that produced eggs, a total of 161 eggs were laid; 38 were found broken, 92 were infertile and 31 were fertile. The mean daily energy intake (kJ/cage) increased significantly once all chicks were hatched and the male budgerigars spent extended periods of the day feeding both hen and chicks in the nest; at peak intake the birds were collectively ingesting daily 483–505 kJ/cage (two adults plus three chicks). At the peak of energy demand the body weight of the cocks fell (8.0 ± 1.0 g lower than their pairing weight), whereas the hens maintained their body weight around the pairing weight. At point C the first chick fledged, and by D all chicks were independent of the parent birds and had been removed to alternative housing. By the end of the breeding period (day 78) the mean daily energy intake had returned to a level of 231–252 kJ/cage and all the cock birds had increased body weight back up to their pairing weight.

Figure 3 shows the data for the growth of budgerigar chicks (n = 16) from hatching until day 30. The chicks were weighed every 2 d and were found to double their birth weight in only 2 d. During the 30 d post-hatching, the mean body weight of the budgerigar chicks had increased from 1.9 g (males, 2.0 g; females, 1.8 g) to 49.8 g (males, 48.3 g; females, 53.6 g), equating to a weight gain of 1.6 g/d. By day 30 they had achieved their adult body size and were no longer dependent on the parent birds.

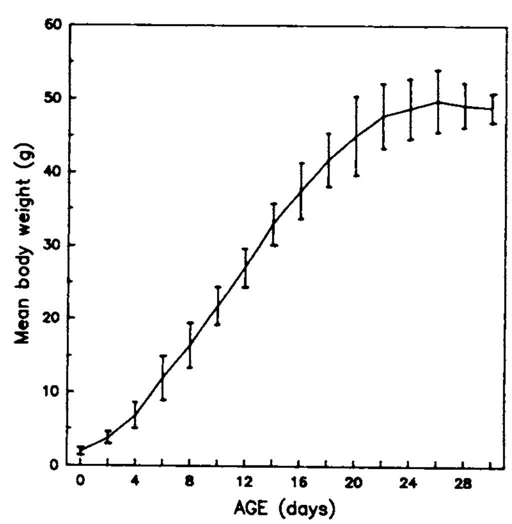

FIGURE 3 Body weight increase (g) for budgerigar chicks (n = 16) from hatching to day 30. Values are means ± SD for chicks.

TABLE 7

Daily food intake, weight change and metabolizable energy (ME) intake for 24 adult budgerigars housed together in groups of 4 over a period of 10 d

	Food Intake	Weight Change	ME Intake
	g/bird		*MJ/kg BW*
White millet	6.9 ± 0.3[1]	0.2 ± 0.1	1.95 ± 0.21
Red millet	8.0 ± 0.8	0.4 ± 0.2	2.15 ± 0.21
Canary	7.1 ± 0.5	0.0 ± 0.3	1.71 ± 0.17
Mixture	8.9 ± 0.5	0.6 ± 0.2	2.77 ± 0.18

[1] Values are means ± SD.

[2] TRILL, a commercial mixture of canary seed, white and red millet.

Having established that the budgerigar has a high daily metabolizable energy requirement for weight maintenance, a study was initiated to measure the availability of major nutrients from a selection of seeds. Budgerigars were housed in groups of four, as in earlier studies, in a bird room where the ambient air temperature was 18–22°C, relative humidity 75–90% and a light cycle of 12 h of daylight and 12 h of dark. The birds were prefed ad libitum quantities of the test diet for 4 d before the 10-d period of excreta collection. Grit was placed in a food hopper to minimize the contamination of feces at the base of the cage. Food intake and wet excreta were measured daily and body weight monitored every 2 d. During the excreta collection period the four budgerigars excreted 3.83 ± 0.69 g wet material/d. Any individual bird losing >10% of its body weight was removed from the trial.

Excreta was also analyzed for uric acid content: aqueous extraction of 0.5 g of dried feces in 200 mL of 0.034 mol/L lithium carbonate 0.081 mol/L boric acid buffer for 15 min over a steam bath. After filtration (0.2 μm filter) the solution was made up to 250 mL and a 10 μL sample was analyzed by high performance liquid chromatography (HPLC) (Spectrophysics SP 8100 with 8400 UV detector, Spectrophysics, San Jose, California, USA) using a 250 mm × 4.6 mm ID 5 μm Sperisorb ODS column (Technicol, Stockport, Cheshire, UK) with 0.1 mol/L KH_2PO_4 as an eluent. The uric acid peak was identified spectrophotometrically at 280 nm. Nitrogen-free extract was calculated by difference. Apparent metabolizability percentages for the major nutrients were calculated from analyses of seed and excreta samples (all figures for seed analyses were based on seed kernels only); no correction factor is needed for urinary losses as avian excreta is the total excretory end product of metabolism. Apparent crude protein metabolizability was calculated after deduction of the uric acid nitrogen from fecal nitrogen figures; all remaining nitrogen was assumed to be ingested protein nitrogen.

Table 7 shows the mean daily body weight change (g) for each bird when fed a series of seed diets of known daily intake for a period of 10 d. In all studies, except canary seed, the birds gained weight and were ingesting significantly more than the 1.59 MJ/kg BW found to be necessary for weight maintenance. It would be pertinent to note that the birds had very little opportunity for flight during these studies, therefore, energy expenditure of free-living budgerigars may be >1.59 MJ/kg BW. **Table 8** shows the percent of each of the major nutrients that were metabolized by these birds from their seed diet. The percentage apparent metabolizability of protein was the variable that varied the most, with mean values ranging from 71.8 to 90.8% of the dietary protein. The percentage metabolizability of each nutrient was high, generally >80%, this figure would support the observation that daily fecal output was only 12–15% of daily wet food intake. Problems encountered during this study were often due to excessive food intakes by some individual birds giving rise to poor quality feces with a high moisture content. As excess weight gain is detrimental to normal flight, these birds were returned to the outdoor aviary and excluded from the study. This methodology is now being routinely employed in our bird room at Waltham to assess the bioavailability of a cross-section of seed materials.

Finally, when assessing a particular dietary regimen for its adequacy in supplying a nutritious diet to the budgerigar, one must consider the relative acceptance of the particular diet. Budgerigars in our aviary at Waltham are known to have individual food preferences as well as individual patterns of feeding behavior. Intake of certain seeds can be improved by soaking, sprouting or mixing with shredded vegetable materials such as lettuce or carrot. It must be remembered that these birds are often slow to accept novel foods, and it may take up to 2 wk before their intake increases to a point where it is of any nutritional value in the diet. This process can be affected by early dietary ex-

TABLE 8

In vivo values for percentage apparent metabolizability of major nutrients by the budgerigars from a seed diet

	Crude protein[1]	Acid-ether extract	NFE[2]	Energy
		%		
White millet	71.8 ± 8.4[3]	90.9 ± 3.8	95.7 ± 0.9	93.4 ± 0.9
Red millet	90.8 ± 3.5	87.2 ± 3.4	92.1 ± 1.3	92.0 ± 1.5
Canary	89.5 ± 2.3	89.0 ± 2.9	88.1 ± 1.9	88.2 ± 1.8
Mixture[4]	73.4 ± 8.7	89.0 ± 2.1	94.7 ± 1.0	92.6 ± 1.4

[1] All crude protein values were corrected for the contribution of uric acid.

[2] Nitrogen-free extract.

[3] Values are means ± SD for n = 24 samples.

[4] TRILL, a commercial mixture of canary seed, white millet and red millet.

perience, and budgerigars will eat most readily the seeds given to them as chicks.

The provision of individually formulated seed mixtures for cage-bred budgerigars has been and will continue to be a fascination for breeders and nutritionists until the individual nutrient requirements of these birds have been identified. Genetic selection of the budgerigar has produced a bird that is phenotypically distinct from its ancestors but whose diet is still considered to be similar to the original native Australian diet (1). In summary, the nutrient requirements of the budgerigar were found to be similar to other domesticated bird species. Studies described above have enabled calculation of the resting energy expenditure of the budgerigar, for both adult and breeding pairs. This will, in turn, promote the selection of dietary seed components based on nutrient availability as well as individual acceptance. Until further work is carried out in the areas of availability of nutrients such as calcium and phosphorus or vitamin A and carotenes it will not be possible to formulate a complete diet for a budgerigar without the use of dietary supplements. Great care should be taken with dietary supplementation to avoid problems of toxicity.

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