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ERIGARS (*Melopsittacus undulatus*) FED

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Michael Underwood

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SHORT TERM ENERGY AND PROTEIN UTILIZATION BY BUDGERIGARS

(*Melopsittacus undulatus*) FED ISOCALORIC DIETS OF VARING PROTEIN

CONCENTRATIONS.

by

Michael Underwood

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ABSTRACT

SHORT TERM ENERGY AND PROTEIN UTILIZATION BY BUDGERIC (*Melopsittacus undulatus*) FED ISOCALORIC DIETS OF VARING PROT CONCENTRATIONS.

By
Michael Underwood

Dietary convertion of budgerigars or budgies (*Melopsittacus undulatus*) from a seed diet to a crumbled diet based on mixed ingredients was dependent upon time and social order. Budgies were fed for 60 days a seed diet or isocaloric mash diets that varied from 12% to 27% protein.

Those fed the seed diet ate significantly more than others and had a higher body weight, higher body fat content, and low body ash content. Birds fed extreme protein levels were thin and experienced high mortality. As dietary protein increased, body fat level, dietary fat utilization, and dietary dry matter digestibility decreased.

Apparent metabolizable energy (AME) and crude protein digestibility remained constant. AME values for budgies were higher for corn and soybean meal, and lower for wheat and oats than NRC values for chickens.

Body measurements were not reliable indicators for determining carcass composition.

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INTRODUCTION

Most cage birds are believed to suffer from a nutritional problem of some type. Obesity and nutritional deficiencies (Wallach and Flieg, 1969) are known to shorten the normally long life span to one or two years. The traditional seed mixture is outdated compared to complete balanced poultry ration. However, poultry nutritional research results can not be directly applied to exotic bird species as their needs probably vary. The carcass analysis is needed as a part of this research as it gives insight into the internal body characteristics correlated to the nutritional part of the diet and can lead to a more complete nutritional study. It was with these considerations in mind that the following study was undertaken in the hope of improving the lives and longevity of cage birds.

LITERATURE REVIEW

There is a need for nutritional information on cage birds that can be used to increase the health and life span of these birds. Most exotic cage birds are fed a mixture of whole seeds free choice in the belief that the birds will choose what they need. This has resulted in many nutritional diseases such as nutritional secondary hyperparathyroidism (Wallach and Flieg, 1973). Several species of psittacines have been shown to naturally develop this disease on the typical all seed diet (Wallach and Flieg, 1969); it can be induced in young budgies *(Melopsittacus undulatus*) within 7 weeks by feeding only a commercial seed mix (Arnold et. al. 1974).

Studies with poultry by Thayer et. al. (1961) revealed that turkeys do not have the inherent ability to balance protein and energy intake when fed mash and whole grain free choice. When young chickens were offered a choice of complete or vitamin deficient diets, Wharton et. al. (1958) noted that these chicks could not instinctively chose a complete diet with regard to thiamine, pantothenic acid, choline, or vitamin D. Fry et. al., (1958) showed that while turkey poults chose some whole grains over others, their selection of grains could be correlated only with the calculated energy content of those grains.

Few nutritional studies have been conducted using members of the parrot family. Weathers and Caccamise (1975) examined the water requirements of the monk parakeet (*Myiopsitta monachus*) and Skadhauge and Dawson(1980b) have studied sodium transport and ion excretion (Skadhauge and Dawson 1980a) in the galah (*Cacatua roseicapilla*), Cannon (1979) calculated that a nectar feeder, the rainbow lorikeet (*Trichoglossus haematodus*), weighing l50 grams, requires 55 kcal/day for maintenance. Roudybush and Grau (1986) studied the water to solids ratio needed in the diet by young growing cockatiels (*Nymphicus hollandicus*). They determined that cockatiels need 7% solids in the diet for the first four days, resulting in an 87% survival rate for that period. Thirty percent solids are then required which produced a 79% survival rate for the period after day four. There has been very little nutritional research done on cage birds compared to domestic poultry. For information on detailed nutritional needs, one must use poultry studies and extrapolate to cage birds. The following studies were all performed using poultry.

Sibbald and Slinger (1963b) concluded that amino acid deficiencies or excesses had little direct effect upon AME (apparent metabolizable energy) values with either the classical or corrected method of calculation. Sibbald et. al. (1960) presented data to suggest that fiber had a slight AME value. They speculated this might have been due to an increase in utilization of the rest of the diet resulting from the diluting effect of cellulose that would allow increased exposure, or slow the rate of passage through the alimentary canal. Carew et. al. (1963) wrote that cellulose appeared to depress energy consumption whenever appreciable quantities were added to the diet.

Biely and March (1957) showed chickens` fat utilization was slightly affected by diet protein content. When the protein level increased, fat utilization decreased. Furthermore, different types of fat were utilized to different degrees. Fuller and Rendon (1979) found no effect on the AME of fat in the diet when fat levels ranged from 5 to 20% of the diet.

Baldini and Rosenberg (1957) reported in chickens that the effect of adding fat to a diet containing a sufficient amount of essential fatty acids was thought to be due entirely to the caloric value of the fat and that either fat or carbohydrate had the same effect when added to a diet at the same caloric level. If the fat content of a diet was increased without increasing the energy concentration of the diet, then no effects on growth, feed efficiency, body composition, or consumption were observed. Vondell and Ringrose (1958) also concluded that calories from fat did not differ from calories derived from other nutrients in their effect upon energy to protein ratios remaining constant across a range of protein levels. The data of Rand et. al. (1958) did not agree with this. Isonitrogenous isocaloric diets with an adequate amount of essential fatty acids produced improved weight gains, greater protein and energy utilization, and greater protein retention when fat calories were substituted for glucose calories. Jensen et. al. (1970) added fat to turkey diets having the same protein concentration and also found feed efficiency greater than expected. This is known as the extra-caloric effect. Sibbald et. al. (1962a, 1962b) believed this effect was chemical and not physical since mineral oil when substituted for vegetable oil or animal fat, did not show the effect that vegetable oil or fat did. Carew, Jr. et. al. (1963) speculated that the effect may have been due to essential fatty acids, possibly linoleic acid present in the oil, or a palatability factor resulting from the consistency of the diet with oil. Even though equal in caloric effect, Donaldson (1964) showed that chicks do metabolize fats and carbohydrates differently.

Some researchers have looked directly at the protein to energy ratio and the factors affecting it. Donaldson et. al. (1956) using chicks and later poults (Donaldson et al,1958) revealed that when feeding diets of any protein level also high in calories derived only from fat, a wider protein to energy ratio could be tolerated before growth rate was impared. Also, Biely and March (1957) concluded that the level of productive energy in the diet affected the efficiency of feed utilization more than growth in chickens. This was true within each protein level fed. These findings should be kept in mind when considering the following data.

Carter et. al. (1957) showed that poults of eight to sixteen weeks of age had an impared feed conversion when fed a diet with a protein level below l4%. When the protein level was 17% or lower, growth rates were less than normal. Summers et. al. (1964) explained that with a low protein diet, chicks would over consume energy in an attempt to satisfy their protein needs. This method of compensation was not effective when protein dropped below 10% of the diet. Also with low-energy high-protein diets, net protein utilization decreased from the use of protein as an energy source (Summers et. al., 1964). Day and Hill (1957) reported that turkeys fed high energy rations were 27% more efficient with regard to feed conversion than turkeys fed low energy rations even though growth rate was approximately equal. Potter et. al. (1956) evaluated diets with protein levels of 20 to 30% and ascertained that as the energy to protein ratio increased in chick diets with constant protein content, growth rate consistently increased to a point and then plateaued, but the gain to feed ratio continued to increase. Dunkelgod and Thayer (1957) reported that turkey growth plateaued at a protein level of 32% but feed efficiency continued to improve up to 36% protein, while Summers and Fisher (1961) showed in poultry, a linear decrease in net protein values with increasing levels of dietary protein from 13 to 27%. Summers et. al. (1964) later found that the feed efficiency response to increased dietary protein was curvilinear (geometric).

Some researchers have also looked at the effect of diet on carcass composition. Harms et. al. (1957) wrote that the type of energy in the diet had an effect on the type of fat in the carcass. This was explored in more detail by Rand et. al. (1957). The chemical composition of carcass fat approached that of dietary fat as the level of dietary fat increased. However, when dietary fat remained constant, high levels of dietary protein tended to decrease the percentage of carcass fat derived from dietary fat. Day and Hill (1957) using poults concluded there was no significant differences in body weights of birds fed isocaloric diets with varying protein levels (22 to 32%), but the body weights of birds fed high energy diets were greater than the body weights of those fed low energy diets. In other words, under those conditions of dietary formulation, the energy level of the diet influenced body weight,while the protein level of the diet did not. The composition of the increased body weight was not determined. Leong et. al. (1955) also reported that the amount of carcass fat in chickens depended on dietary fat levels.

Most researchers felt that the protein to energy ratio was the important determinant. Harms et. al. (1957) cited an increase in the percent of eviscera (which included tissue as well as fat) in chickens as the energy level of the diets (altering the protein to energy ratio) was increased. Donaldson et. al. (1955, 1956) showed a widening of the energy to protein ratio that resulted in increased fattening with a corresponding reduction in carcass water content. Donaldson et. al. (1958) later noted similar results with turkey poults. As the energy to protein ratio was widened within each fat level, there was increased fat deposition in the carcass. Rand et. al. (1957) showed that the amount of fat in the carcass was inversely correlated with the protein to energy ratio and with the ratio of protein intake to the relative growth rate. Unlike other researchers, they interpreted this as the apparent relationship of dietary fat level to amount of carcass fat always reflected the effect of dietary energy level on protein intake. They claimed that the carcass fat content was unaffected directly by either the energy level or fat level of the diet. Scott et. al. (1957) reported that as the protein level increased in isocaloric duck diets, the fat level in the carcass decreased. Age may have an effect on this ratio since Roberson and Francis (1963) detailed that with geese, carcass "grade" was not affected by protein or energy level of the diet when the geese were l6 to l8 weeks old; however at l4 weeks, the lower energy concentration produced a lower carcass "grade". It has also been shown by Polin and Hussein (1982) and Carew et. al. (1972) that fats and oils were not absorbed maximally by chicks less than two weeks of age, but that bile acid supplementation improved the absorption (Polin and Hussein, 1982).

Hill and Dansky (1954) showed that when protein level was varied from 16 to 20%, there was little effect on total feed or energy consumption during early growth. Scott et. al. (1982) outlined the general ability of the chicken to keep energy consumption constant by consuming more diet when the energy was low, confirming the data of Hill and Dansky (1954). The chicken was able to do this successfully when the diets ranged from 2500 to 3300 kcal/kg. Anderson (1964) described breeding turkeys that regulated their feed intake to keep energy consumption constant at protein levels of l4.5 or l6.5% when AME was increased by 80 kcals from 2860 kcal/kg. Hardaker (1973) discovered that intake was inversely related to energy concentration in broiler chicken diets when the energy varied between 2300 to 3600 kcal/kg. Hill and Dansky (1954), however, concluded that while growing chicks could adjust feed intake based on energy level in the diet, the progressively increased rates of consumption with reduced energy level from adding oat hulls, were not sufficient to maintain total energy intake equal to that on the control diet. Diets varied from 2145 kcal/kg to as low as 1111 kcal/kg. Energy consumption rates progressively declined as dietary energy level was reduced, and were reflected in corresponding changes in the carcass fat content. The decrease in total energy intake was due to an insufficient feed intake. Carew et. al. (1963) wrote that cellulose appeared to depress energy consumption whenever appreciable quantities were added to the diet. The results of Hill and Dansky (1954) were supported by Morris (1968). After a review of the literature, Morris concluded that although consumption was adjusted to maintain the same caloric intake, this adjustment was not perfect for diets exceeding 3200 kcal/kg, and resulted in laying birds on high energy diets consuming more energy and thus gaining more weight than those fed lower energy diets. Energy consumed per unit of gain during growth was essentially equal for a range of energy levels, according to Matterson et. al. (1955) and Fuller and Rendon (1979). Polin and Wolford (1973) revealed that the upper digestive tract, particularly the crop, was involved with regulating feed intake, and that responses to fill capacity override the energy needs. Thus, fiber used to dilute dietary energy initially caused an increase in feed intake but once the crop was full, hunger was no longer optimal and feed intake ceased until some emptying of the crop occurred. Kurnick et. al. (1961) discovered that the production rate of laying hens could be lowered by feeding a low energy diet that did not allow the hens to consume adequate amounts of energy due to the high fiber content of the diet.

The protein to energy ratio has been shown to affect the utilization of individual nutrients. Donaldson et. al. (1958) wrote that as the protein to energy ratio was increased in an isocaloric diet, turkey poults consume more energy than needed normally in an effort to obtain other required nutrients. This added energy was deposited as fat. Renner and Hill (1960) concluded that there was no major effect on the overall energy utilization of other nutrients when the dietary fat level was increased. Rosenberg and Baldini (1957) showed in chickens that when diets were kept isocaloric and the protein levels varied, the energy content of the diet governed the methionine requirement. As long as there was sufficient energy from non-protein sources, the methionine requirement expressed as a percent of the diet increased as protein level increased. If some protein was burned for energy, then the methionine content of that protein was not important. Gordon et. al. (1958) concluded that amino acid requirements as a percent of protein were constant over a wide range of protein levels provided that the protein to energy ratio was constant. Ferguson et. al.

(1957) related that in turkey poults the interaction of energy and methionine was significant. They increased energy by 220 kcal/kg at three different protein levels (24, 26, and 28%) and found the response to supplemental methionine greatest at the higher energy level at each of the protein levels. The energy to protein ratio has been shown to interact with at least one other nutrient as well. Davis et. al. (1958) reasoned that the percent of calcium needed in the low energy diet is less for laying hens since they eat more diet. Edwards Jr., et. al. (1960) wrote that the type and level of fat in the diet affects calcium utilization.

Many biological factors may influence the effect of nutrition on birds. While Thornton et. al. (1957) told of a sex difference in chicken growth response to protein levels, Sibbald et. al. (1960) concluded that the age differences with regard to metabolizable energy in poultry from two weeks of age and up were very small, if differences even existed at all. This was not the conclusion of Renner and Hill (1960). They discovered that tallow was poorly utilized by chicks under eight weeks of age. Carew et. al. (1972) ascertained that chicks were able to utilize corn oil maximally after two weeks of age. If the fat level was increased in the diet before 15 days of age, the chicks would increase the amount of fat in the excreta. It has also been shown by Polin and Hussein (1982) that fats and oils are not absorbed maximally by very young chicks. Carter et. al. (1957) concluded that body size (i.e. breed) may influence protein requirement in the turkey. Moreng et. al. (1964) in four strains of laying hens fed three levels of protein, found statistically significant differences existed within the specific characteristics measured, including egg quality and feed efficiency. Anderson (1964) described an energy effect on feed intake that varied in turkey breeds, but Siegel and Wisman (1962) ran trials on both high and low genetic weight lines of chickens that responded similarly to various rations.

Feather picking by parents of chicks in the nest is considered a major problem with cage birds. Several researchers had found a link between diet and feather picking in poultry. Donaldson et. al. (1955) reported in broiler chicks that as the energy level of the feed increased in relation to crude protein, feather picking and poor feather quality were observed. Clandinin and Robblee (1958) have shown that over a range of protein levels fed to pheasant chicks, there was a constant ratio with energy that produced the least feather picking. Turk et. al. (1961) concluded that with pullets, levels of productive energy above 2200 kcal/kg of feed tended to produce difficulties from feather picking and feather eating which could only be partially relieved by increasing the protein in the diet. The addition of feather meal was actually detrimental. Cain et. al. (1976) discovered that feather picking by pheasants was reduced as dietary energy content was increased from 2530 to 2970 kcal/kg and then picking increased slightly at 3190 kcal/kg.

For the formulation of practical diets, the apparent metabolizable energy (AME) value of ingredients is needed. The method for determination of meaningful AME values for poultry has been demonstrated by Matterson, et. al. (1958) and Sibbald, et. al. (1960). They used ingredient substitution at the expense of glucose into a basal diet which was tested for gross energy (GE) as was the excreta produced by birds on these diets. Scott et al. (1982) gave the following formula for determining the AME/g of the substituted ingredient: AME/g = 3.64-((AME/g reference diet-ME/g diet with substitute)/proportion of substitute). The determined value for glucose is 3.64. Potter and Matterson (1960) have determined AME values of 27 common poultry feedstuffs. For the ingredients tested the following AME values were found: corn, 3366 kcal/kg; soybean meal (44% protein), 2244 kcal/kg; oats, 2508 kcal/kg; and wheat, 2904 kcal/kg. These values differ for other species (Sibbald, et. al., 1960).

OBJECTIVES

1) To determine the optimal protein to energy ratio for a budgerigar (budgie) (*Melopsittacus undulatus*) maintenance diet based on feed efficiencies and carcass composition. 2) To determine for budgies the AME value of four common feedstuffs.

METHODS

Unsexed budgies, approximately five weeks old, were obtained from a commercial source. The budgies were kept in an isolated room under positive pressure at 20 C at the Poultry Teaching and Research Center of Michigan State University. They were on a 15:9 hours (light:dark) cycle using incandescent bulbs. Food and water were provided daily; cages were cleaned once each week. Two groups of 99 and 97 birds were converted from eating seeds to a commercial formulated diet in the form of a crumble. They were kept in 10 colony cages (47.5 cm high, 81 cm wide, and 50 cm deep). A third group of 63 birds was placed three to a cage (22.5 cm high, 24 cm wide, and 50 cm deep) part way through feed conversion.

Sibbald and Slinger (1963a) have shown that chickens became acclimated to a new diet within 24 hours with regard to fiber and AME, and rarely required as long as three days to become fully acclimated. The feed passage time through chickens is approximately 167 minutes (Golian and Polin 1983). Budgies resist a change from seeds to crumbled diets and must be gradually converted. All budgies in these trials were converted from a commercial seed mix of 11% protein to a crumbled diet of 20% crude protein . At first, they were given a mixture of 50% seeds and 50% crumbles, the latter mixed with enough vegetable oil to make it appear moist. This mix was fed to the birds in quantities small enough to prevent picking out as many seeds as they would normally eat. Over several weeks, the amount of seeds was slowly reduced and finally eliminated. Then the amount of vegetable oil was slowly reduced and eliminated, resulting in feeding the crumbled diet alone. If an individual bird's appearance seemed abnormal at any time during feed conversion, it was separated and fed only seeds until it recovered. Then feed conversion for that bird was attempted again. Experience with the conversion procedure indicated that if feed conversion was too rapid, starvation mortality would result which was verified by postmortem results.

EXPERIMENT 1

All birds were fed a crumbled diet with 20% crude protein for several weeks before Experiment 1. After conversion from a whole seed diet to a 20% protein crumbled diet, 120 birds were divided into 40 small cages (22.5 cm high, 24 cm wide, and 50 cm deep) with three birds per cage. Sex of birds was not considered in the placement of individuals into the cages. The groups were divided among the following treatments:

Diet No.	Protein	Number of Birds
01	11% seed	24
02	12% mash	24
03	17% mash	24
04	22% mash	24
05	27% mash	24

These diets were provided in mash form, simmilar in consistency to the crumbles fed until this time. There were eight cages for each treatment with three birds per cage, totaling 24 birds on each treatment. Diet compositions are given in Table 1. Initially, diets were formulated with wheat bran and fed as a mash. This resulted in birds picking out the other feed ingredients and leaving the wheat bran. Presumably only if the diet was pelleted or finely ground would the budgies eat wheat bran. The birds avoided eating finely ground diets or large pellets in preference to medium size particles, so diets were formulated without wheat bran and provided in mash form for this experiment. All ingredients in the mash were then eaten.

All birds were weighed weekly, and feed intake for each cage of three birds was determined weekly for the duration of the experiment. All birds were measured for girth, grade and pelvic distance weekly. The girth was the circumference (cm) around the thorax at its greatest point measured with a cloth tape. The grade was a number subjectively assigned from one to five, with five being the most "fat", determined by palpating the pectoral and abdominal areas. The pelvic distance was the measurement (mm) between the end of the keel and the pelvic bones. One half of the birds (20 groups) were euthanized on day 28 with excess carbon dioxide, and one half of those sacrificed were kept for whole carcass analysis. The remaining half of live birds were euthanized on day 56, with half retained for carcass analysis. The half not used for carcass analysis was used in a separate experiment. In the latter experiment, excreta samples were collected for one week on aluminum foil suspended under each cage. This collection procedure was found to be inadequate as some excreta and spilled feed were lost. Thus, total collection of each was not achieved.

At the end of the experiment, other birds from the same source were used to obtain AME (apparent metabolizable energy) values of the diets. They were housed l3 to 19 birds in each cage (50 cm deep, 47.5 cm high, and 81 cm wide), and the excreta collected in 5 cm deep aluminum trays. The collection was for three days after a two day acclimation to the experimental diets. In this second collection, minimal losses of excreta and feed were noted. This second collection provided the data for AME. Seed hulls are discarded by budgies fed whole seeds. Since the hulls are impossible to account for quantitatively, no attempt was made to analyze the seed diet and excreta for gross energy and thus AME.

The following analyses were performed. Diets, excreta, and defeathered carcasses were each dried in a vacuum oven at 60 to 80 degrees C to determine dry weight. Samples of diet, excreta, and the entire defeathered carcass were extracted in a soxhlet apparatus for l2 hours with petroleum ether for lipid (ether extract) determination on a dry weight basis. Diet and excreta were bombed in a Parr adiabatic calorimeter for gross energy determination. Samples of diet, excreta, and defeathered carcass were used for protein (nitrogen) determination by the micro Kejldhal method. All statistical analyses were performed on an Apple Macintosh computer using the StatView computer program (BrainPower, Inc. 24009 Ventura Blvd.,Suite 250, Calabasas, Ca. 91302).

EXPERIMENT 2

For the second experiment (AME and digestablilty), some birds were divided into five colony cages. Each group was fed ad. lib. one of the following treatments:

Diet No.	Test Ingredient	% In Diet	Number of Birds
06	glucose(basal)	40	13
07	soybean	40	13
08	corn	40	13
09	oats	40	13
10	wheat	40	14

The glucose basal diet was formulated similar to Sibbald, et. al. (1960). Each remaining treatments substituted 40% of the test ingredient for an equivalent amount of glucose. After a three day acclimatization to the experimental diets, the four-day collection period began. During this time, samples of feed and excreta were collected quantitatively (using the total collecting method) for gross energy determination with a Parr adiabatic bomb calorimeter. Daily feed intakes were recorded by weighing back the feed containers each morning.

RESULTS

The success of conversion of budgies from seeds to crumbles varied greatly (Table 2). One group had only a 70% survival rate, while subsequent conversions had 90% and 98% survival rates. The difference in survival rates between total colony conversion (90% and 98%) and conversion in small cages part of the time (70%) was considerable. The group with only 70% survival was placed solely on dry crumbles on day 24, while the other two were not placed on dry crumbles until complete conversion on day 32 (98% survival) and day 63 (90% survival).

EXPERIMENT 1

The daily intake per bird was greatest on the all seed treatment. That group averaged 7.56 g/day intake each, while the other groups averaged between 5.75 to 6.54 g/day (Table 3). Analysis of the feed intake data revealed (Figure 2) there was a significant decrease ($p=.0089$) in feed intake as the protein level increased. Further fitting by polynomial regression illustrated that the seed diet was accounting for the major significant ($p=.0006$) difference (Figure 3) and feed intake for the other diets had plateaued. Results of regression analysis on weekly feed intake for all treatments revealed there was a slight decrease ($p = .0439$) in feed intake as the experiment progressed (Figure 4). Polynomial regresssion of these data illustrated that during weeks 4 to 7, feed intake declined but then increased to approach the amounts orginally consumed in the earlier weeks 1 and 2 ($p=.0296$) (Figure 5).

All birds averaged 29.5 g in weight at the start of the trial. Weekly weight gains are presented in Table 4. If intake is compared as a percent of body weight, it can be seen that across a range of diets and individuals, the average bird consumed feed at 22% of its body weight daily. The following were intakes as a percent of body weight for each of the diets: seed=26%, 12% protein=21%, 17% protein=28%, 22% protein=26%, and 27% protein=25%. All values were similar except for that from the birds fed the 12% protein diet, which was lowest. A 2 factor repeated measure ANOVA of weekly body weights revealed significant differences among treatments (Table 5). Regression analysis of weekly body weights showed that the body weights were more uniform at the 2 highest protein levels (p=.3638) (Figure 6). If an overall weight gain is calculated for the entire eight week experiment (Table 6), one can note that the birds on the seed diet had a mean weight increase of 4.5 g. This gain was significantly (p<.05) greater than all other treatments.

Many birds on the 12% diet lost weight but with their crops packed with food, seemingly prevented from increasing feed intake due to excessive bulky diet. This full crop hid the body weight decline when the birds were weighed weekly. Birds exhibited food seeking behavior even though the feed cups were kept one third full at all times.

Analysis of carcasses obtained on days 28 and 56 for % crude protein, % crude fat and dry matter weight did not reveal any significant differences for length of time on a particular treatment. Therefore, 28- and 56-day data on carcass composition were pooled for an ANOVA of dietary treatments (Table 7)

These data indicated that dry total carcass weight averaged between 8.99 and 10.14 g (p>.05) and the estimate of between component (treatment) variance was -0.06. There was no significant difference between any two treatments (Table 7). The ANOVA of percent protein in the carcass on a dry weight basis also detected no significant differences between any two groups (Table 7). The percent protein of dry carcass averaged 64.3%. The birds fed the seed diet had the highest percentage of carcass fat at 30.4%. There was a negative relationship. As the protein level of the diet increased from 12 to 17%, the percent carcass fat decreased. That represented a 20% decline in body fat. There was a 95% confidence level that the birds fed seeds had more carcass fat than the birds fed 27% protein, and a 90% confidence level that carcass fat was higher than for the birds fed 22% protein. The fat-free, dry weights of protein plus ash revealed that seed-type diets resulted in ash of 8.5%, as compared to 11.4 to 16.6% of this total for the other diets.

An ANOVA on data from measurements of the pelvic distance and grade indicated no significant difference ($p>.1$) among the treatments. However, an ANOVA on the data on the eighth week girth change indicated significant differences ($p=.006$) (Table 8). The girth measurement of budgies on all treatments, other than the all-seed treatment, decreased slightly though not significantly, when all eight weeks were taken into account (table 8). The girth of seed-eating budgies increased by 0.075, and was significantly different ($p<.05$) than the change for each of the other treatments. Thus, the girth measurement reflected the increase of the live body weights of birds fed seeds. Girth measurements for the other treatments decreased and appeared to reflect the decline in body weights (Tables 6 and 8). When live weight gains and girth changes for the 8th week were evaluated for a relationship between the two measurements, there was no evidence (two tailed $p=.31$) for a direct relationship between the two. The girth measurement was too variable to be used as an indirect measurement of weight increase or of an overweight condition. Also when a paired t test was done on girth gains and body fat, it was found that the was no direct relationship. Although girth, carcass fat, and body weight all increased in the all-seed treatment, there was no direct correlation between them in a sample of this size.

The analysis of the second feed and excreta collection trial (Experiment 1) are presented in Table 9. It appeared from the data that the dry matter digestibility (1-(excreta wt./feed intake wt.)) declined, from 78% to 69%, as the protein level of the diet increased from 12% to 27%. The AME (80%) and the crude protein percent digestibility(44%) both were almost constant for all treatments. Summer et. al., (1964) found the protein retention of poultry to be slightly higher at around 53% for diets of similar energy levels. The AME was near 3.4 kcal/g for all treatments. This was higher than the value of 3.0 kcal/g calculated from the National Research Council (NRC) tables. This resulted in a 13% increase in AME for budgie utilization of the diets as compared to chickens.

EXPERIMENT 2

The dry intake of birds on the diet with 40% sugar was highest at 5.3 g/bird/day while the intake of the birds fed the oat diet was lowest at 3.6 g (Table 10). Those on all other diets consumed about 4.3 g. The dry intake values reflected the kcal/retained/day. The birds fed the control diet retained the highest level of energy, 25.71 kcal/day. Birds fed the oat diet were the lowest, 13.9 kcal. The corn and soy fed birds retained 21.7 kcal and the wheat fed birds, 19.7 kcal/day.

Both corn at 4.41 kcal/g and soybean meal at 3.78 kcal/g had a higher AME value than listed by NRC for chickens, 3.35 and 2.23 respectively. The wheat and oat values were lower than NRC, 2.31 vs 3.12, and 1.22 vs 2.55, respectively.

DISCUSSION

The difference in survival rates for total colony feed conversion (90% and 98%) and conversion in small cages part of the time (70%) suggests one explanation: more birds learned to eat the new foods in a colony situation. The higher conversion mortality of budgies in small groups as compared to those converted in a colony situation seemed to indicate a more favorable environment for conversion in the latter situation. Being in a colony could have encouraged reluctant birds to mimic the others eating the crumbles. However, determining whether each bird was eating adequately was more difficult than when there were three to a cage. Another possibility suggested by the difference in survival rates was that increased conversion time may have been responsible for the reduced mortality. In all probability both explanations were involved.

Three birds and one feed cup were placed into each cage at the beginning of the Experiment 1. We did not expect a social order to develop and individual birds to dominate the feed intake of the others, but in certain cages, such an effect seemed evident. Several birds starved to death as a result of this environment. By day thirteen we added an extra feed cup to each cage which stopped starvation losses. Near the end of the experiment, more birds died, but this time diet appeared to be responsible. When the mortality data were examined in detail (Figure 1), deaths resulting from social dominance were greatest in the middle protein ranges while the deaths due to diet were greater in the 27% protein treatment. The birds with socially induced starvation died quickly and retained most of their body weight, which was unlike the body condition of birds that died due to dietary causes. The latter birds were slow to die and lost most of their muscle mass. This body weight decrease was not reflected in the weekly weighings. Dead birds were found with food packed in their crops, and this may have accounted for our inability to detect the slow decline in body weights of some birds in a group. There were no deaths in the seed treatment groups.

No mortality was experienced in Experiment 2. If there were any nutritional imbalances in the diets, they did not cause problems in the span of this short trial. These birds were housed in a large colony situation and thus a strong social dominance did not develop.

Birds on a wide percent protein range in diets consumed on average, just under one quarter of their body weight in food each day. Birds will increase energy intake above normal in an attempt to increase protein intake to an adequete level (Summers et. al. 1964). This trend was reflected in the feed intake data of budgies in Experiment 1 fed the seed-type diet and those fed the mash diet with the lowest protein concentration. As the protein level increased toward a presumed adequate level in the diet, the birds consumed less diet. Based on these data, 12% protein in the diet appears too low for budgies.

The birds fed seeds continued to put on weight throughout the 60 day trial and may have increased even more had the trial not been terminated. This gain was in the form of body fat. As the protein level increased in the diet, the body weight gains of the birds decreased. Therefore, the large weight gain (4.4 g) on the seed diet may have been due to two different conditions. The first was the imbalanced nutrients in the all seed diet; the second was the low (11%) level of protein in the seed with an incorrect protein/energy ratio. The seed diet also was the only one determined to have an incorrect (Ca:P) ratio. The seed-type diet resulted in a marked reduction in ash content, a reflection of skeletal loss from inadequate mineral concentration of the diet.

Since all the carcass composition measurements had stabilized by day 28 of the first experiment, a 56-day trial is not necessary for carcass composition studies in the future.

The birds fed seeds in Experiment 1 had the highest carcass fat level of all treatments. As the protein concentration of the isocaloric mash diets increased, the percent carcass fat decreased. These findings agree with the work done on ducks by Scott et. al. (1957). They found that as the protein level increased in isocaloric diets, the fat level in the carcass decreased. These data were also in agreement with the work of Donaldson et. al. (1955 and 1956) on turkeys and chickens. As the protein to energy ratio widened, more fat was deposited in the carcass. Seed-type diets appear to have improper protein to calorie ratios and thus force the deposition of carcass fat, while the 27% protein diet resulted in birds that were very thin.

Although Biely and March (1957) have shown that fat utilization decreased as protein level went up in the diet, there was only a slight suggestion of that in the apparent metabolizable energy results of Experiment 1. The decrease in dry matter digestibility might be attributed to the widening energy to protein ratio rather than the unavailability of the protein or energy directly.

The AME of the diets for budgies was higher than the value expected from poultry had the latter been fed the same diets. The budgies seemed more able than chickens to utilize the nutritional value of the diets. These data on digestibliliy only apply to the actual feed ingredients as used in combination with each other, and the results may change if any substitutions are made in the formulation of the diets. This was illustrated in the results of Experiment 2.

In Experiment 2, budgies seem more capable of extracting energy from certain ingredients than expected from poultry data. Both corn and soybean meal had values substantially higher than NRC values. This trend was in general agreement with the results of the first trial in which the AME of mixed rations was also higher than values calculated for poultry using NRC tables.

The AME value obtained for oats in the second trial was very low, which could have been caused by excessive bulk of the diet in influencing feed intake, as noted in poultry by Polin and Wolford (1973). Great difficulty was experienced in inducing the birds to consume the entire diet. The hulls even though ground up were selectively avoided perhaps due to their resemblance to seed hulls which budgies normally discard. The same problem was encountered with wheat bran (Methods section). In the future, either oat groats must be used or the whole oat diet must be ground, pelleted and crumbled. The wheat grain was well taken in this trial; the slightly lower than NRC value for wheat may reflect a wheat intolerance. Further trials would be required to substantiate this.

Although several researchers have claimed a connection between dietary protein to energy ratio and feather picking in chickens (Clandinin and Robblee, 1958 and Donaldson et. al., 1955), feather picking was not observed in any group of budgies.

CONCLUSIONS

The difference in survival rates between total colony feed conversion (90% and 98%) and conversion in small cages for part of the time (70%) and length of conversion were considerable. This, and the social order that developed which caused an individual bird to dominate the feed intake of cagemates indicate that behavior may have played a large role in this nutritional study.

The pelvic distance and grade indicated no significant difference (p>.1) among the treatments. The girth measurement reflected the increase of the live body weights of the birds fed seeds. Although girth, carcass fat, and body weight all increased in the all-seed treatment, there was no direct correlation between them in a sample of this size. Therefore the three clinical parameters used to determine body condition in this trial were not sufficiently accurate.

While birds on a wide range of mash diets consumed on average, just under one quarter of their body weight in food each day, the birds on the all seed diet consumed more. Seed eaters had the highest carcass fat level and highest body weight of all the treatments. Budgies increased energy intake above normal in attempting to increase protein intake to an adequete level. Also seed-type diets resulted in a marked reduction in ash content. Due to the incorrect nutrient balance, low mineral content, reverse Ca:P ratio, low protein (11%) level, and the incorrect protein/energy ratio of the seed diet, it does not meet the nutritional needs of the budgie.

Many birds on the 12% diet lost weight but died with their crops packed with food. As the protein concentration of the isocaloric mash diets increased, the percent carcass fat decreased. Fat utilization and dry matter digestibility decreased as protein level increased in the diet. The 27% protein diet resulted in thin birds. There was a 20% decline in body fat over other treatments. This diet caused high mortality and is not suitable for the budgie. Therefore, both the low and high protein mashes were incorrectly balanced and illustrate the clinical consequences caused by either exteme of the protein/calorie ratio.

The AME (80%) and the crude protein percent digestibility (27%) both were almost constant for all treatments. There was a 13% increase in AME for budgie utilization of the diets as compared to chickens. Budgies seem to be more capable of extracting energy from certain ingredients than would be predicted from poultry data. Both corn and soybean meal had values substantially higher than NRC values. Oats and wheat were slightly lower. When formulating diets for budgies in the furture, consideration must be given to the differences in chicken and budgie utilization of feedstuffs.

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Tables

Table 1
Composition of diets in experiment 1

Treatment	seed	12% prot.	17% prot.	22% prot.	27%prot.
Ingredient(parts/Kg)					
white proso millet	600	0	0	0	0
canary grass seed	200	0	0	0	0
oat groats	200	0	0	0	0
alfalfa,17% dehyd.	0	80	80	80	80
corn,#2 yellow	0	769.85	649.75	510.70	420.05
corn gluten meal,60%	0	20	40	100	190
soybean meal,44%	0	60	160	220	220
limestone,38% Ca	0	9	9	9	9
dical. phos.,18%	0	22	26	26	26
corn oil	0	24	24	40	40
choline chloride,50%	0	1	1	1	1
vitamin mix[1]	0	3	3	3	3
mineral mix[2]	0	3	3	3	3
salt iodized	0	4	4	4	3.5
lysine HCl	0	1.9	1.6	1.6	2.9
methionine, dl	0	0	0.4	0.4	0.3
ethoxyquin	0	1.25	1.25	1.30	1.25
Se premix[3]	0	0.05	0.05	0.05	0.05
Total	**1000**	**1000**	**1000**	**1000**	**1000**
Moisture	6.56	7.84	7.43	6.56	6.94
Analytical analysis on dry wt. basis(%)					
crude protein	12.76	14.84	17.82	23.79	30.65
crude fiber	---[4]	7.9	8.8	10.3	10.9
fat	4.50	5.04	5.07	6.12	6.01
Ca	0.02	1.26	1.14	0.89	0.94
P	0.36	0.84	1.07	1.04	0.82
Mg	0.12	0.19	0.22	0.18	0.19
K	0.27	0.61	0.81	0.81	0.82
Se	---	0.14	0.17	0.13	0.17
Calculated ME	---[5]	3.344	3.440	3.446	3.482
Calculated Prot./ME[6]	---[5]	4.44	5.17	6.90	8.80

1 supplies per Kg: vitamin A, 11,880 I.U.; vitamin D3, 600 I.C.U.; vitamin E, 10 I.U.; vitamin K, 2.2 mg; vitamin B12, 0.05 mg; Riboflavin, 6mg; d-Pantothenic acid, 2.1 mg; Niacin, 42 mg; Thiamine, 4.2 mg; Pyridoxine, 6 mg; Folic acid, 1.2 mg; Ascorbic acid, 0.5 mg; d-Biotin, 0.2 mg.

2 supplies per Kg: Mn, 60 mg; Zn, 40 mg; Fe, 30 mg; Cu, 5 mg; I, 0.5 mg.

3 supplies per Kg: Se, 0.1mg.

4 seed is hulled when eaten, seed meat has only trace of fiber.

5 calculation of ME not possible, birds not consume total diet

6 %/(kcal/g)

Table 2

Procedure for conversion of budgies from seed to crumble diet

Group 1	63 birds		
day 1	fed seeds in colony cages		
day 5	fed 50% seeds/50% crumble diet*		
day 6	1 dead		
day 7	1 dead		
day 11-23	reduce seed and oil		
day 24	birds from colony cage to 3 per cage		
day 24	feed dry crumbles alone		
day 24-44	17 dead		
Total	Alive 44	Dead 19	**survival rate 70%**

Group 2	99 birds		
day 1	fed seeds in colony cages		
day 5	fed 50% seeds/50% crumble diet*		
day 6	1 dead		
day 8	1 dead		
day 12-31	reduce seed and oil		
day 32	feed dry crumbles alone		
day 51	birds from colony cage to 3 per cage		
Total	Alive 97	Dead 2	**survival rate 98%**

Group 3	97 birds		
day 1	fed seeds in colony cages		
day 10	fed 66% seeds/33% crumble diet*		
day 14	1 dead		
day 19	place on 50% seed/50% crumble diet*		
day 22	3 dead		
day 23	1 dead		
day 28	1 dead		
day 29	1 dead		
day 38	place on 75% seed/ 25% crumble diet*		
day 63	feed dry crumbles alone		
day 65	1 dead		
day 67	1 dead		
day 69	1 dead		
Total	Alive 87	Dead 10	**survival rate 90%**

*crumble diet has 5% corn oil added

Table 3

Intake(g)/budgie/day of mash diets of varying protein levels, experiment 1

Treatment		seed (11%)	12% prot.	17% prot.	22% prot.	27% prot.	Mean of all diets for week
week 1							
	(X)	5.8	7.9a	7.8	7.8	7.5	7.4
	(SE+-)	0.7	2.1	1.7	2.8	2.2	
	(N)	8	8	8	8	8	
week 2							
	(X)	8.1	6.8a	6.1a	6.3a	6.2a	6.7
	(SE+-)	0.6	0.6	0.9	1.0	0.9	
	(N)	7	8	8	8	8	
week 3							
	(X)	8.0	6.2a	5.7a	5.4a	5.3a	6.2
	(SE+-)	1.4	1.5	1.0	0.6	0.3	
	(N)	8	8	8	8	8	
week 4							
	(X)	7.9	7.1	6.3a	6.3a	6.2a	6.7
	(SE+-)	0.7	0.7	1.2	1.1	0.6	
	(N)	8	8	8	8	8	
week 5							
	(X)	7.3	5.9	4.7a	6.0	5.7	5.9
	(SE+-)	0.7	0.8	1.3	1.9	0.9	
	(N)	4	4	4	4	4	
week 6							
	(X)	7.5	6.1	5.0a	5.6a	4.8a	5.8
	(SE+-)	0.7	1.0	1.1	1.3	0.9	
	(N)	4	4	4	4	4	
week 7							
	(X)	7.5	5.6a	4.6a	4.8a	4.8a	5.5
	(SE+-)	1.0	1.0	1.1	1.2	1.4	
	(N)	4	4	4	4	4	
week 8							
	(X)	8.1	6.8	5.7a	6.6	6.6	6.8
	(SE+-)	0.5	1.1	1.5	1.5	1.3	
	(N)	4	4	4	4	4	
Mean daily intake for Treatment over 8 weeks		7.6	6.5	5.8	6.1	5.9	6.38

a significantly different from the seed diet that week

Table 4

Weekly weight gains of budgies (g) in experiment 1

treatment:	seed(11%)	12% protein	17% protein	22% protein	27% protein	mean[a]
start wt.	28.71 (X)	30.50	28.63	29.67	29.92	
	2.10 (SD+ -)	2.32	1.86	2.73	2.39	
	24 (n)	24	24	24	24	
GAIN[c]						
week 1	3.78	2.73	2.92	4.33	2.81	**3.31**
	1.90	1.44	2.31	1.59	1.55	**0.71**
	24	24	23	24	24	**5**
week 2	-0.38	-0.32	-0.15	-0.08	-0.25	**-0.24**
	1.14	1.32	1.37	1.22	1.22	**0.12**
	24	23	19	24	23	**5**
week 3	0.18	0.48	0.83	-0.14	0.16	**0.30**
	0.49	1.61	2.07	1.11	1.11	**0.37**
	24	23	19	23	22	**5**
week 4	-0.41	0.95	1.21	-0.04	0.20	**0.38**
	0.77	1.03	1.96	0.94	0.94	**0.68**
	24	22	19	23	22	**5**
week 5	1.08	-0.25	-0.64	-0.17	-0.33	**-0.06**
	0.81	0.91	0.76	1.28	1.28	**0.66**
	12	11	09	10	12	**5**
week 6	0.34	-0.41	0.09	-0.88	-0.24	**-0.22**
	0.89	1.96	1.86	2.65	2.65	**0.47**
	12	11	08	10	09	**5**
week 7	0.23	0.65	1.31	-2.61	-0.09	**-0.10**
	1.83	0.83	1.63	3.71	3.13	**1.50**
	12	10	08	10	08	**5**
week 8	0.00	-3.86	-3.21	-0.27	-1.38	**-1.74**
	0.54	3.00	3.31	2.58	2.58	**1.73**
	12	10	08	10	08	**5**
end wt.	33.63	31.54	29.90	32.07	32.68	
	3.49	3.03	2.79	3.93	0.91	
	12	10	08	10	08	
mean[b]	0.56	0.00	0.30	0.02	0.11	
	0.66	1.86	1.79	1.94	1.20	
	8	8	8	8	8	

a mean gain for all treatments each week
b mean gain for each of 8 weeks for each treatment
c value is wt. gain of that week only, not cumulative

Table 5

Stastical ANOVA on weekly weight gains of budgies from experiment 1

Anova table for a 2-factor repeated measures Anova.

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value
treatment (A)	4	19.224	4.806	2.991	.029
subjects w. groups	43	69.103	1.607		
Repeated Measure (B)	7	707.351	101.05	28.986	1.0E-4
AB	28	280.39	10.014	2.872	1.0E-4
B x subjects w. groups	301	1049.336	3.486		

There were no missing cells found. 79 cases deleted with missing values.

AB Incidence Table [1]

Treatment: seed(11%) repeated measure (weight):		12% protein	17% protein	22% protein	27% protein	totals
week 1	12	10	8	10	8	48
	3.817	2.540	3.312	4.820	2.812	3.508
week 2	12	10	8	10	8	48
	-0.092	0.200	0.412	0.060	-0.475	0.021
week 3	12	10	8	10	8	48
	-0.058	0.720	0.475	0.030	0.025	0.225
week 4	12	10	8	10	8	48
	-0.592	1.440	0.912	0.390	0.188	0.417
week 5	12	10	8	10	8	48
	1.075	-0.480	-0.225	-0.170	-0.175	0.067
week 6	12	10	8	10	8	48
	0.342	-0.530	0.088	-0.880	-0.950	-0.352
week 7	12	10	8	10	8	48
	0.233	0.620	1.438	-2.510	-0.088	-0.110
week 8	12	10	8	10	8	48
	0.000	-3.860	-3.212	-0.270	-1.375	-1.625
totals	96	80	64	80	64	384
	0.591	0.081	0.400	0.184	0.000	0.269

Note: 79 cases with missing values were deleted for this statistic and therefore the means do not match the means of table 4, which did not require the deletion of values.

Table 6

4 and 8 week weight gains (g) of Budgies in experiment 1

Treatment	start wt.	n	4 Week Mean Gain	n	8 Week Mean Gain
seed (11%)	28.71	24	3.01	12	4.47
12% Prot.	30.50	22	3.61	10	-0.05*
17% Prot.	28.63	19	5.05	08	0.90*
22% Prot.	29.67	23	3.32	10	-0.54*
27% Prot.	29.92	22	2.90	08	-0.35*

*significantly different from seed (11%)
at 95% confidence with Fisher PLSD

Table 7
Budgie Carcass Composition in experiment 1
(W/O feathers)

	mean of day 28 data				
Treatment[1]	seed (11%)	12% prot.	17% prot.	22% prot.	27% prot.
Dry Wt.(g)	9.95	9.46	9.85	8.47	9.27
%Protein Dry Wt.	63.69	63.94	61.60	65.34	67.33
% Fat Dry Wt.	32.13	23.86	25.23	21.01	23.10
%Ash Dry Wt.	4.18	12.20	13.43	13.65	12.57

	mean of day 56 data				
Treatment[2]	seed (11%)	12% prot.	17% prot.	22% prot.	27% prot.
Dry Wt.(g)	10.33	9.92	6.83	9.42	9.47
%Protein Dry Wt.	63.72	66.63	72.45	66.38	59.97
% Fat Dry Wt.	28.65	29.13	21.35	27.77	23.61
%Ash Dry Wt.	7.63	4.24	6.20	5.85	16.42

	mean of pooled day 28 and day 56 data				
Treatment[3]	seed (11%)	12% prot.	17% prot.	22% prot.	27% prot.
Dry Wt.(g)	10.14	9.68	9.28	8.99	9.36
%Protein Dry Wt.	63.70	65.14	62.95	65.91	64.06
% Fat Dry Wt.	30.39	26.50	24.61	24.70	23.33
%Ash Dry Wt.	5.91	8.36	12.44	9.39	12.61
Prot./Prot+Ash	0.915	0.886	0.834	0.864	0.836

% water not available due to blood collection on kill date for a separate experiment
1 n=6 for 11%, 5 for 12%, 5 for 17%, 5 for22%, 5 for27%
2 n=6 for 11%, 5 for 12%, 1 for 17%, 6 for22%, 4 for27%
3 n=12 for 11%, 10 for 12%, 6 for 17%, 11 for22%, 9 for27%

Table 8

Eight-week girth [1] gains of Budgies in experiment 1

Treatment	Diet No.	n	Mean Gain	Std. error(+-)
seed (11%)	01	12	0.075	0.108
12% Prot.	02	10	-0.650	0.181
17% Prot.	03	08	-0.425	0.167
22% Prot.	04	10	-0.540	0.136
27% Prot.	05	08	-0.350	0.151

One factor ANOVA

Comparisons

diet no.	Mean difference
01 vs 02	0.725*
01 vs 03	0.500*
01 vs 04	0.615*
01 vs 05	0.425*
02 vs 03	-0.225
02 vs 04	-0.110
02 vs 05	-0.300
03 vs 04	0.115
03 vs 05	-0.075
04 vs 05	-0.190

*significantly different at 95% confidence with Fisher PLSD

1 girth measurement was abdominal circumference in cm

Table 9

Feed digestibility for Budgies in experiment 1

DIET[1]	12%	17%	22%	27%
Number of birds in sample	13	17	19	18
Dry intake(g)/bird/day	5.90	6.63	4.87	5.43
Dry excreta(g)/bird/day	1.28	1.35	1.37	1.70
Dry matter digestibility (%)	78	80	72	69
Feed GE (kcal/g)	4.117	4.163	4.417	4.562
Excreta GE (kcal/g)	3.563	3.553	3.452	3.451
Energy retained (%)[2]	81	83	78	76
kcal. retained/day	19.73	22.81	16.78	18.91
Feed ME(kcal/g)[3]	3.344	3.440	3.446	3.482
Feed NRC ME(kcal/g)[4]	3.034	3.003	3.035	3.066
ME determined/NRC est.	1.134	1.147	1.135	1.136
Feed crude protein (%)[5]	14.84	17.80	23.79	30.65
Excreta crude protein (%)[5]	37.97	45.57	50.06	56.28
Crude protein retained (%)	44.5	47.9	40.3	42.5

1 Calculation of the seed diet omitted due to invalid data because birds selectivly eat only part of diet.

2 % energy retained = $\frac{\text{(intake wt.)(feed GE)-(excreta wt.)(excreta GE)}}{\text{(intake wt.)(feed GE)}}$

3 ME/g = % energy retained x feed GE/g

4 calculated values based on poultry data from National Research Council

5 determined values

Table 10

Grain digestibility for Budgies in experiment 2 [1]

DIET	Control	soybean	corn	oat	wheat
Number of birds in sample	13	13	13	13	14
Dry intake/bird/day (g)	5.31	4.42	4.29	3.58	4.55
Dry excreta/bird/day (g)	0.97	1.00	0.96	0.96	0.92
Dry matter digestibility (%)	81	77	78	73	80
Feed GE (Kcal/g)	5.754	6.023	6.210	5.254	5.332
Excreta GE (Kcal/g)	4.928	4.878	5.151	5.107	4.987
Energy retained (%)[2]	84	82	82	74	81
kcal. retained/day	25.71	21.71	21.70	13.92	19.68
Feed ME (Kcal/g)[3]	4.857	4.912	5.058	3.888	4.325
Grain ME(Kcal/g)[4]	--	3.778	4.143	1.218	2.310
NRC ingredent ME(Kcal/g)[5]	3.640	2.230	3.350	2.550	3.120

1 control diet contained glucose, other diets substituted grain for glucose at 40%

2 % energy retained = $\frac{\text{(intake wt.)(feed GE)} - \text{(excreta wt.)(excreta GE)}}{\text{(intake wt.)(feed GE)}}$

3 ME/g = % energy retained x feed GE/g

4 grain ME/g = 3.64 - ((ME/g control diet - ME/g substituted diet) / .40)

5 values based on poultry data from National Research Council

Figures

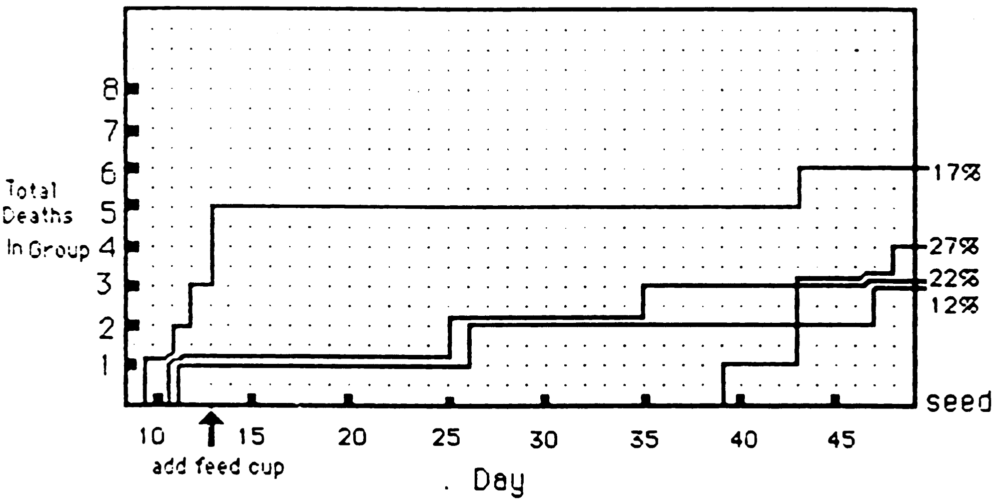

Figure 1
Budgie mortality in experiment 1

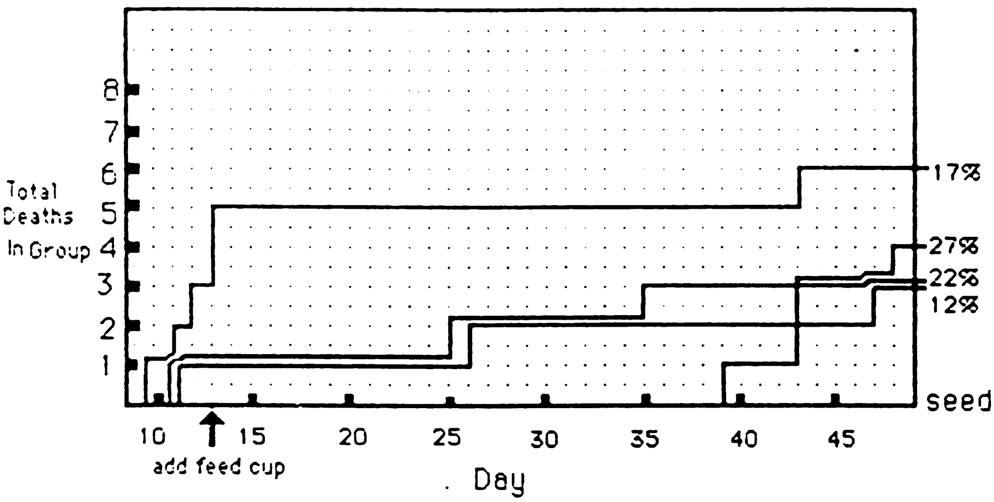

Figure 1
Budgie mortality in experiment 1

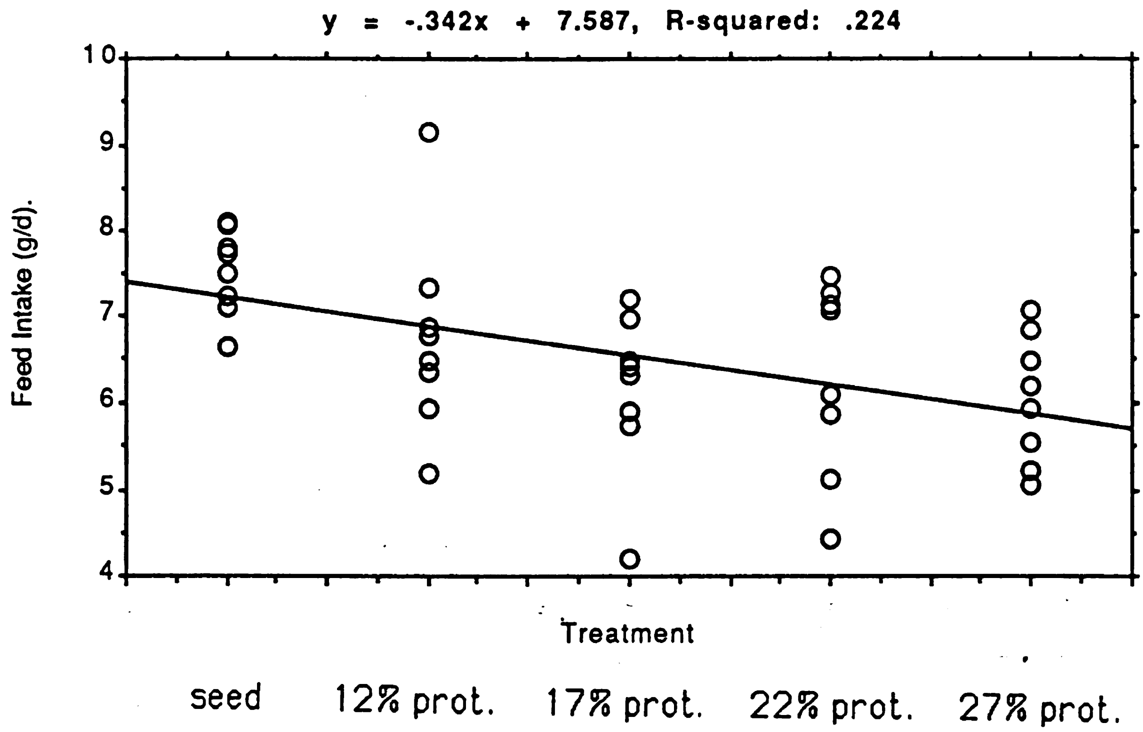

Figure 2

Simple regression analysis for each treatment for 8 week feed intake of budgies in experiment 1

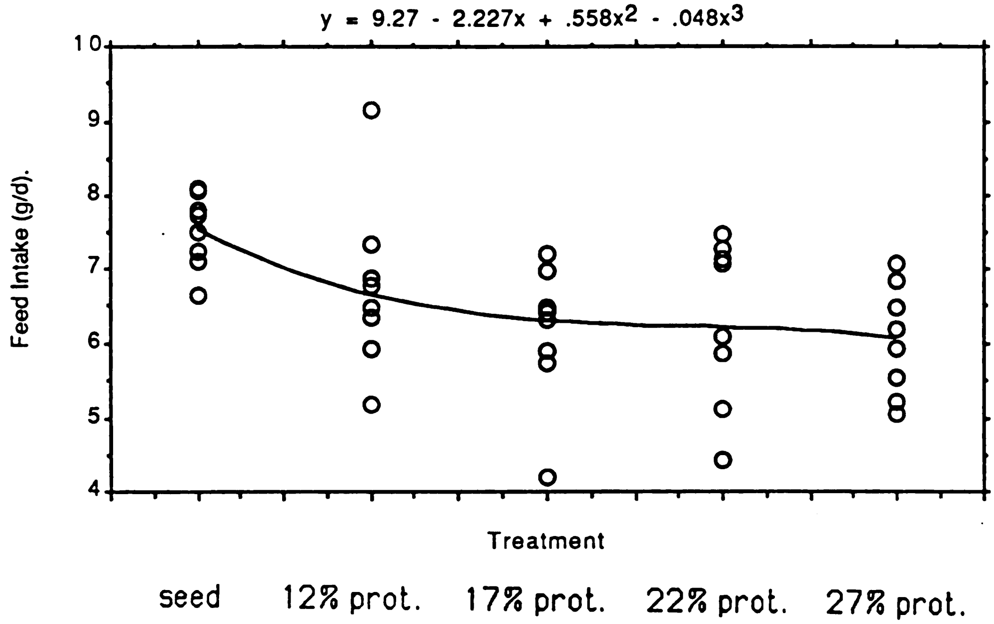

Figure 3

Polynomial regression analysis for each treatment for 8 week feed intake by budgies in experiment 1

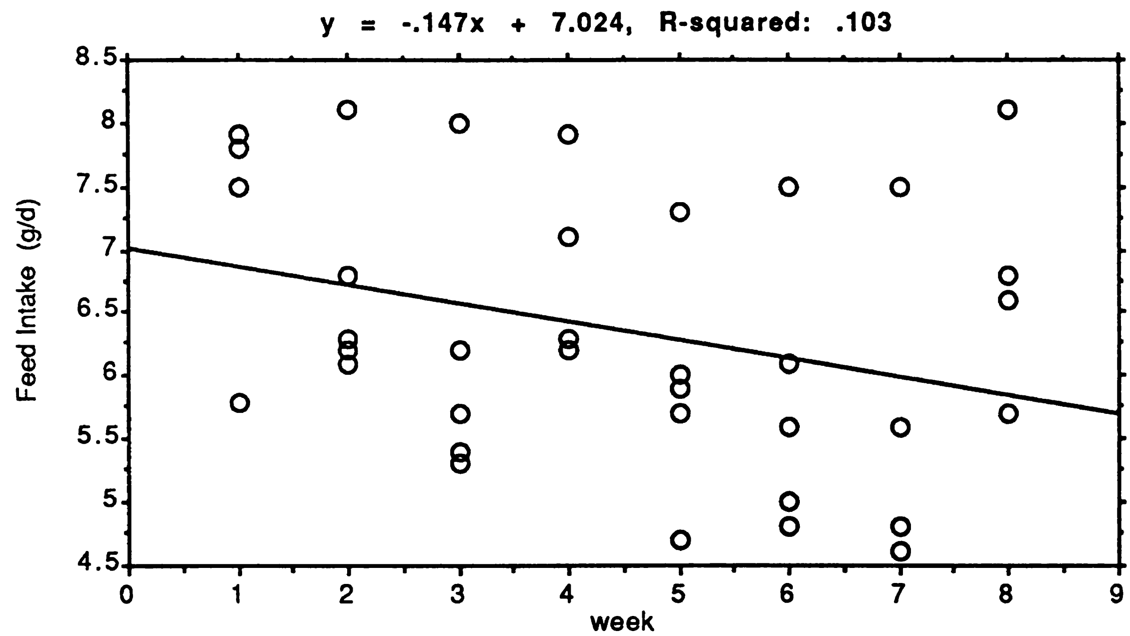

Figure 4
Simple regression analysis of feed intake by budgies in experiment during 8 weeks.

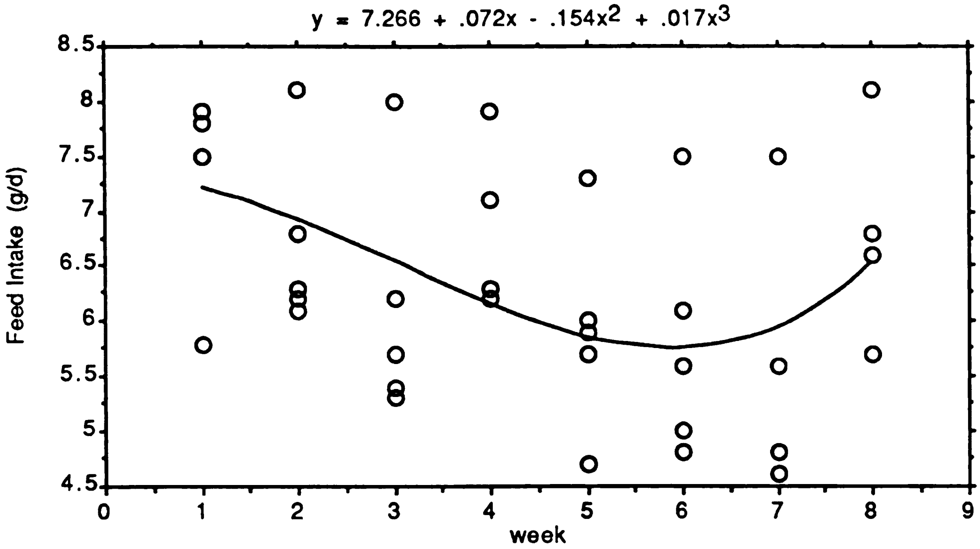

Figure 5

Polynomial regression analysis of feed intake by budgies in experiment 1 during 8 weeks.

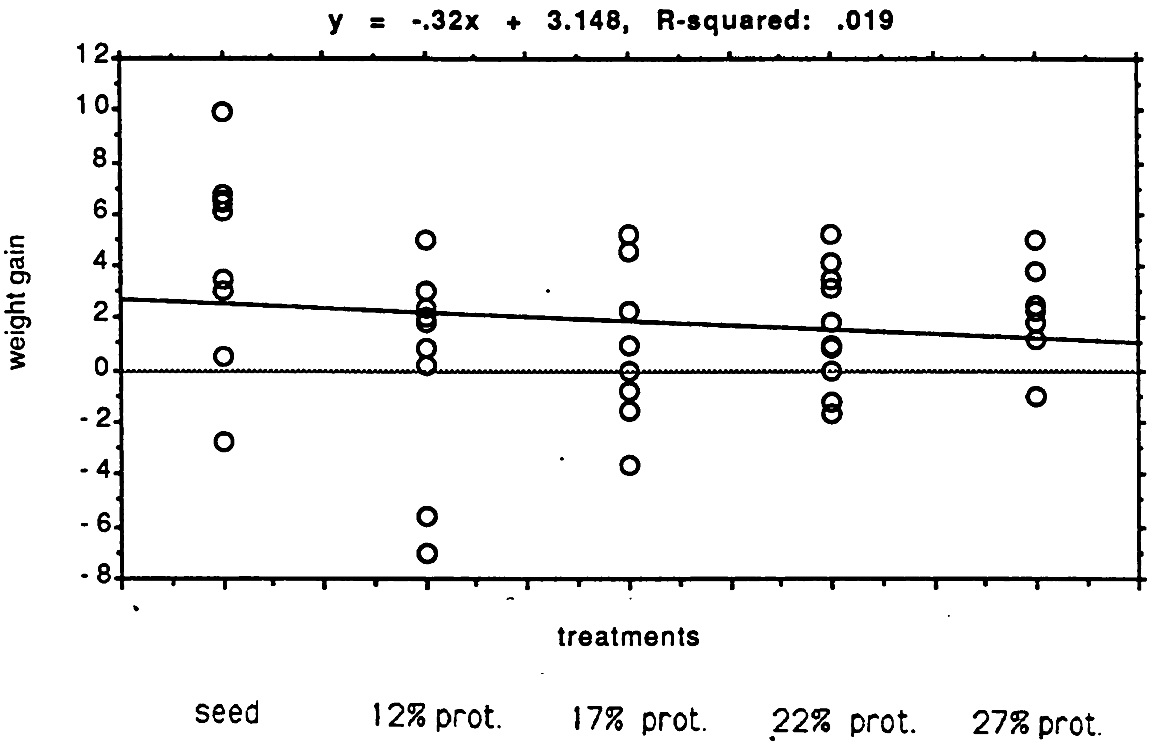

Figure 6

Regression analysis of weight gains (g) of budgies in experiment 1