The cat has traditionally been regarded as having a higher protein requirement than other mammals, but research has been hampered by a lack of knowledge of amino acid needs. This investigation assessed the protein requirement of adult cats through the use of a nitrogen balance technique and the feeding of a semi-purified diet with amino acid levels adjusted to those which have been recently reported to be adequate for kitten growth. Regression analysis of test diets containing approximately 17, 13 and 10% protein (in a diet with a caloric density of 5 kcal/g) indicated a level around 12.5% as the requirement, and this protein concentration was then fed to cats for 32 weeks. Nitrogen balance and bodyweights were maintained, and no health problems were observed. Although lower than previously reported values, this figure is still higher than other mammals' requirements, and the results provide further evidence that the cat is unable to adapt to a low protein intake.

The Protein Requirement of Adult Cats for Maintenance

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Introduction

The cat has traditionally been regarded as having a protein requirement that is higher than that of other mammals. Greaves and Scott[6] concluded that 21% protein (on dry matter) was necessary to maintain resting adult cats in nitrogen equilibrium, while a number of other reports[4,7,8] indicate that protein requirements for growing kittens are met only by diets containing a protein level in the region of 30%. Nevertheless, these early experiments were complicated by a lack of information on the essential amino acid requirements of the cat.

Work conducted over the last 5 or 6 years has more closely defined the amino acid requirements of growing kittens through the use of purified amino acid diets, and these results have recently been summarized.[10] Furthermore, if all the essential amino acids are present at the correct concentrations, maximum growth can be achieved with only 16% protein in such a diet.[1]

The present investigation was designed to measure the protein nitrogen needs of the adult cat in light of this new information on amino acid requirements and then to test the result over an extended feeding period.

This work was first reported as a communication to a meeting of the British Nutrition Society.[3]

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TABLE 1
Composition of Basal Semi-purified Diet (27% Protein)

Dietary Component	% of Diet
Promine D[1]	29.00
Sucrose	13.00
Starch[2]	14.10
Beef tallow[3]	30.20
Cod liver oil[4]	3.60
Solka floc[5]	1.00
Methionine	0.20
Cystine	0.20
Taurine	0.10
Choline chloride	0.40
Mineral mix[6]	8.10
Vitamin mix[7]	0.06

[1]Central Soya Co., Chicago, Illinois.
[2]Pre-gelatinized cornstarch (B37), Laing National Ltd., Manchester, England.
[3]Heat rendered + 0.02% BHT. Overall level of BHT in diet adjusted to 0.01%.
[4]Super Solvitax, British Cod Liver Oils Ltd., Hull, England. Supplies (in IU/100 g diet): Vitamin A 2892; Vitamin D 362.
[5]Added to facilitate fecal collections.
[6]Supplying (in g per 100 g diet): $CaCO_3$ 1.44, $CaHPO_4$ 1.78, K_2HPO_4 1.0, NaCl 2.47, $MgSO_4 .7H_2O$ 0.27, (in mg per 100 g diet): ferric citrate $.5H_2O$ 148, $ZnCl_2$ 20.8, $MnSO_4 .4H_2O$ 8.7, $CuSO_4 .5H_2O$ 2.4, KI 3.1, Na_2SeO_3 0.15.
[7]Supplying (in mg per 100 g diet): thiamine-HCl 10.2, riboflavin 2.1, pyridoxine-HCl 1.3, nicotinic acid 9.1, calcium-d-panthothenate 3.6, folic acid 0.35, cyanocobalamin 0.26, biotin 0.01, 2-ambo-α-tocopherol acetate 13.9.

Materials and Methods

ANIMALS

In the first part of the study, 19 crossbred adult cats (17 neutered males, two intact females) with an initial mean Bodyweight (BW) (±SD) of 3.92±0.75 kg (8.62±1.65 lb) were used. For the second part of the study, the same number of adult cats (16 neutered males, three intact females) were used, but only 12 of these had also been used in the first experiment. The cats replaced were those which had shown indifferent acceptance of the diet. The mean BW (±SD) of the second group was 4.21±0.78 kg (9.26±1.71 lb).

All animals were housed individually in fiberglass cages with internal dimensions of 90 x 60 x 54 cm (35 x 23 x 21 in) (wxdxh) in a temperature-controlled room [20±2°C (68±4.5°F)] on a controlled 12 hour (from 0700 to 1900) light, 12 hour (1900 to 0700) dark cycle. Each cat was trained to urinate and defecate in a fiberglass tray which occupied about one-third of the floor space of the cage and was sloped toward one corner so that urine drained rapidly into a glass jar attached to the underside of the cage. This method of collection generally gave negligible cross-contamination of urine and feces.

DIETS

A semi-purified diet based on a soy protein isolate (Promine D:Central Soya Co.) was used throughout the investigation. The basal diet used for prefeeding contained approximately 27% protein; its composition is shown in Table 1.

The three experimental diets were formulated to contain about 17, 13 or 10% protein by adjusting the level of Promine D in the mixture. Where necessary, the concentrations of essential amino acids in all diets were increased (by the addition of the pure L-isomer) to the levels recommended for kitten growth using the data summarized by Baker.[2] Diets were kept isocaloric at a calculated metabolizable energy content of approximately 5.0 kcal/g (Table 2).

Experimental Design

PHASE 1

All cats were fed the 27% protein diet for 1 month to accustom them to the new feeding regimen and to ensure that they were all in positive nitrogen balance at the start of the investigation. The cats were then divided into three groups balanced for sex and BW. The groups were fed the three test diets in a modified Latin square design with each feeding period lasting 4 weeks. Each cat was fed 15 g diet/kg BW/day (plus 5 g to ensure that the amounts were adequate) as one meal with access to food allowed for 24 hours. At the end of each 24-hour period, the remaining food was weighed and replaced with fresh diet. Water was available *ad libitum.* Cats were weighed weekly before feeding. Urine (acidified with 0.5 M sulphuric

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TABLE 2
Composition of Test Diets

Dietary Component[1]	Diet 1 (%)	Diet 2 (%)	Diet 3 (%)
Promine D	18.00	12.00	7.00
Sucrose	23.50	23.50	23.50
Starch	14.20	18.90	21.70
Arginine HCl	—	0.03	0.46
Histidine HCl	—	0.06	0.20
Isoleucine	—	—	0.01
Leucine	—	0.42	0.77
Lysine HCl	—	0.23	0.58
Methionine	0.30	0.36	0.41
Cystine	0.31	0.36	0.41
Phenylalanine	—	—	0.18
Tyrosine	—	0.12	0.29
Threonine	0.24	0.44	0.61
Tryptophan	—	0.01	0.07
Valine	—	0.11	0.33
Crude protein[2]	16.40	12.90	10.00

[1]All components other than those listed are present at the same concentrations as in the basal diet.
[2]Crude protein (Nx6.25) by Kjeldahl method.

acid) and feces were collected during the last 14 days of each feeding period. Food and urinary and fecal nitrogen were measured by Kjeldahl analysis for calculation of nitrogen balance. Differences between means were analyzed statistically using Duncan's multiple range test.[5] The results were also examined by least squares regression analysis of nitrogen balance against intake to determine at what point zero balance occurred. At the beginning and end of this phase, fasting blood samples were taken from the cephalic vein for determination of hematology, plasma protein and urea values.

PHASE 2

At the end of the first phase of the investigation, the cats were fed the 27% protein diet for 1 month to ensure that they were all in positive nitrogen balance. All cats were then fed the diet containing about 12% protein for 32 weeks at the same rate of food intake used in the first experiment. Two 14-day collections of feces and urine were carried out (during Weeks 9-10 and 16-17) for nitrogen balance measurements. All other conditions were the same as those described for Phase 1.

Results

PHASE 1

In general, the diet was accepted by the cats. One or two animals did not eat enough food to be included in the nitrogen balance measurements, however. Apparent digestibility coefficients (Table 3) show significant differences only for nitrogen which decreased with decreasing protein level in the test diets. These differences are given in greater detail in the nitrogen balance data (Table 4). As expected, the nitrogen intakes were significantly lower with decreasing dietary protein levels. Urine and fecal nitro-

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TABLE 3
Apparent Digestibility Values of Test Diets[1]

Factor	Diet 1 (n=18)	Diet 2 (n=19)	Diet 3 (n=18)
Dietary protein (%)	16.4	12.9	10.0
Nitrogen[2]	86.0±1.1[a]	80.1±1.2[b]	75.7±1.6[c]
Fat[2]	73.9±2.6	69.8±2.6	70.0±2.3
Nitrogen free extract[2]	94.9±0.9	96.6±0.7	97.1±1.0
Organic matter[2]	85.3±1.2	83.6±1.3	83.3±1.2
Energy[2]	81.6±1.8	78.8±1.8	78.4±1.6

[1]Results expressed as mean±SEM; n=number of cats. Means not sharing a common superscript letter in the same row are significantly different ($P < 0.05$) by Duncan's Multiple Range test.

[2]$\text{Apparent digestibility} = \frac{\text{(Nutrient intake} - \text{fecal nutrient output)}}{\text{Nutrient intake}} \times 100$

TABLE 4
Food Intake and Nitrogen Balance Data for Three Levels of Dietary Protein Over 14-Day Collection Period[1] (Phase 1)

Factor	Diet 1 (n=18)	Diet 2 (n=19)	Diet 3 (n=18)
Dietary protein (%)	16.4	12.9	10.0
Food intake (g/day)	44.0±2.9	44.6±3.0	38.0±2.8
Digestible energy intake (kcal/day)	204±13.6	198±14.5	165±13.2
Nitrogen intake (mg/day)	1184±77[a]	923±61[b]	589±43[c]
Urine nitrogen (mg/day)	888±63	774±58	713±68
Fecal nitrogen (mg/day)	169±19	180±14	140±11
Nitrogen balance (mg/day)	127±57[a]	−31±66[a]	−264±68[b]
Initial bodyweight[2] (kg)	3.77±0.19	3.72±0.19	3.75±0.19
Final bodyweight[2] (kg)	3.77±0.20	3.66±0.19	3.59±0.20
Weight change[2] (g)	−5±46[a]	−72±43[ab]	−161±33[b]

[1]Results expressed as mean ± SEM; n=number of cats. Means not sharing a common superscript letter in same row are significantly different ($P<0.05$) by Duncan's Multiple Range test.
[2]Bodyweight results are for the complete feeding period (28 days) of each diet.

gen also showed decreasing values in the same direction, but they were not significantly different between diets. The nitrogen balance results show a positive value for Diet 1 and a small negative value for Diet 2. However, because there was a large standard error, these values were not significantly different. The large negative nitrogen balance for the lowest protein diet was significantly different from the others. The nitrogen balance data indicated that the middle protein level (Diet 2) was close to the concentration necessary for adult maintenance.

An alternative approach to assess nitrogen requirement is to use a graphical technique in which nitrogen balance is plotted against intake and the requirement is then the intercept on the intake (x) axis, *i.e.,* when

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TABLE 5
Food Intake and Nitrogen Balance Data for 12-13% Protein Diet
Over Two 14-Day Collection Periods[1] (Phase 2)

Factor	Collection 1 (n=19)	Collection 2 (n=18)
Food intake (g/day)	53.0±2.8	57.2±3.0
Digestible energy intake (kcal/day)	226±11.9	244±12.8
Nitrogen intake (mg/day)	1044±56	1143±61
Urine nitrogen (mg/day)	775±41	881±60
Fecal nitrogen (mg/day)	184±14	203±19
Nitrogen balance (mg/day)	85±26	59±19
Number of cats in positive balance	14	13
Initial bodyweight[2] (kg)	4.21±0.18 (n=18)	
Final bodyweight[2] (kg)	4.05±0.26 (n=18)	
Weight change[2] (g)	−157±143	

[1] Results expressed as mean ± SEM; n = number of cats.
[2] Bodyweight results are for the entire feeding period (32 weeks).

balance (y) is zero. Results for each individual cat on each diet are included on the graph (Fig. 1). Least squares analysis of the results gave a correlation (r value) of 0.51 ($P < 0.001$) and an intercept on the x axis of about 280 mg nitrogen/kg BW/day. Based on a food intake of 15 g/kg BW/day, this translates to a protein concentration (in the semi-purified diet with a caloric density of 5 kcal/g) of about 12%, which again suggested that Diet 2 was close to supplying the protein need for maintenance. We, therefore, decided to feed this protein level for a much longer period in Phase 2 of the study.

PHASE 2

Mean food intakes during Phase 2 of the study were generally better than those in Phase 1. This was probably a result of the replacement of several cats which had not accepted the diet well. In this phase, only one cat showed a decline in food intake large enough to warrant its removal from the test (after 11 weeks). All the other cats received the diet for the full duration of this study.

The nitrogen balance data (Table 5) show small positive values for both collections with the majority of cats in positive balance. There were no significant differences between any corresponding parameters for the two sets of results.

Although there was a slight fall in the group mean BW during the study, initial and final values were not significantly different. Most of the decrease in mean weight occurred in the first few weeks; the figure for the third week (4.04±0.17 kg) was, in fact, slightly less than the final value.

Hematology and blood chemistry values were within normal ranges before and after both phases of the study. All cats appeared healthy throughout the investigation.

Discussion

The purpose of this investigation was to determine the protein requirement for adult cats under maintenance conditions. From the results of both phases of the study, it appears that an average protein intake of about 7 g/cat/day just satisfied this requirement. This intake approximated to 1.75 g protein/kg BW/day or a protein concentration of about 12.5% in the semi-purified diet

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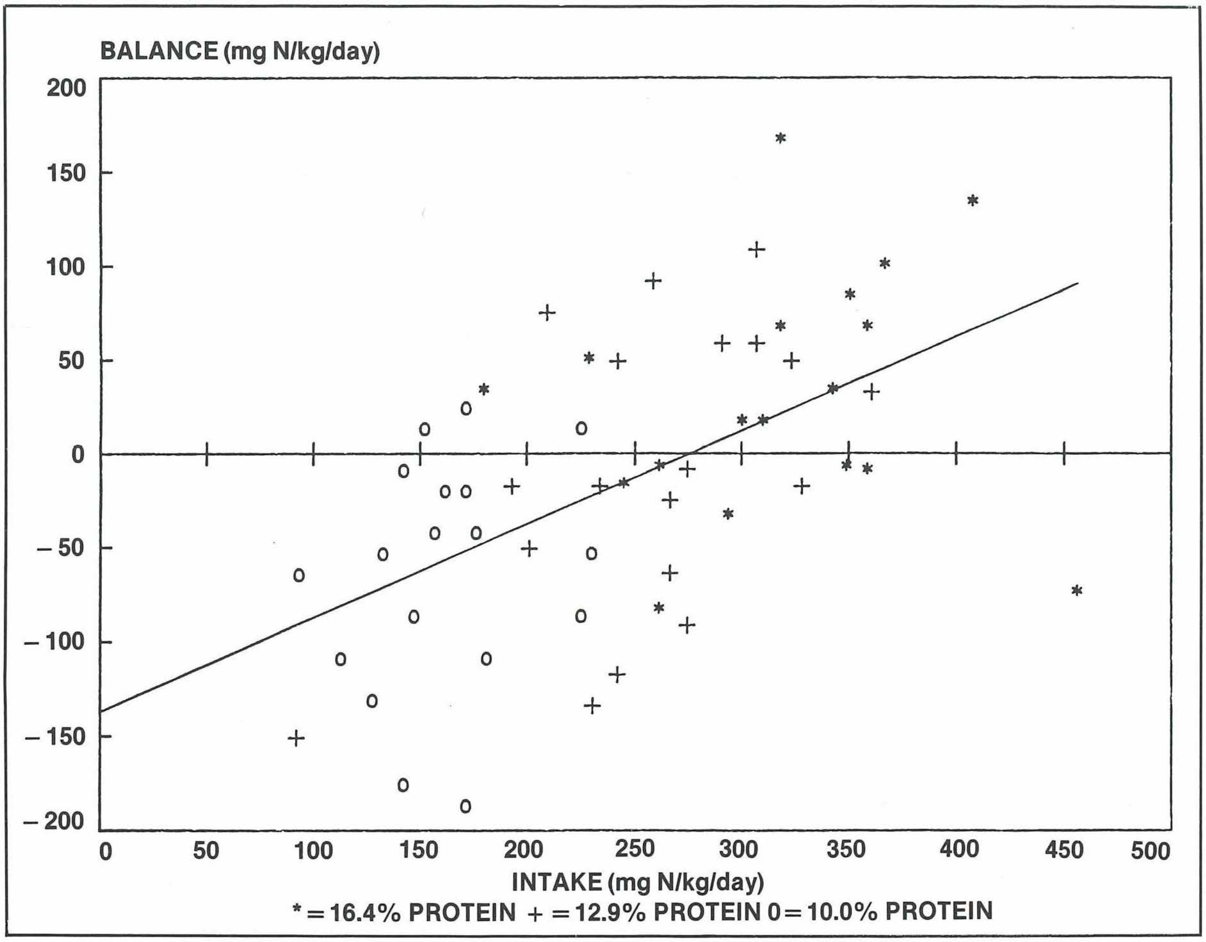

Fig. 1 — Nitrogen balance against intake: first feeding trial.

providing 5 kcal of metabolizable energy per g. It should be noted that the percentage of protein needed in the diet will increase as the caloric density of the diet increases and vice versa.

Although palatability of the diet was a problem with some cats, in general it was better than we might have reasonably expected since the cat is not renowned for its eagerness to eat whatever is offered. The mean digestible energy intake during Phase 2 was about 60 kcal/kg BW/day which is slightly lower than the National Research Council recommendation of 70 kcal/kg BW/day for inactive cats.[9] Despite this, the bodyweight data suggest that most cats were consuming sufficient food for satisfactory weight maintenance.

Nevertheless, in this investigation the most important consideration is protein, *i.e.*, nitrogen balance, and care must be exercised in interpreting the results. All the errors in nitrogen balance measurements tend to be in the positive direction: intake is overestimated (*i.e.*, some food measured as eaten is in fact wasted), and output underestimated (through incomplete collection of urine and feces). Thus, in Phase 2 the cats may have been in slightly negative nitrogen balance. It would be unrealistic, therefore, to regard the values calculated above as final and absolute. Equally, our result is unlikely to be a gross overestimate of the adult cat's minimum protein requirement; and, although lower than earlier measurements by other research workers, it is still substantially higher

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than values reported for other species such as the dog, rat and man.[10]

The remarkable similarity of the urinary nitrogen outputs for the three diets in Phase 1 is a good indication of the cat's inability to regulate its protein breakdown rate when faced with a low-protein diet. It is this peculiarity which is thought to be mainly responsible for the cat's relatively high protein requirement.[10]

In this investigation we had the advantage of being able to adjust dietary amino acid levels to values which are known to be adequate for kitten growth and, therefore, to be more than satisfactory for adult cats. Would it be possible to formulate a commercial diet to 12.5% protein using commonly available raw materials and still achieve a satisfactory amino acid profile? At present, it would certainly be difficult, but it begs the additional question of what is a satisfactory amino acid profile. This aspect of adult cat nutrition has yet to be studied in any detail; but when the information is available, it will be possible to match dietary amino acid levels more precisely to the cat's requirements. This in turn should make it feasible to formulate diets with crude protein levels at or even below 12.5% which support bodyweight and nitrogen balance in adult cats. ■

REFERENCES

1. Anderson PA, Baker DH, Sherry PA, Corbin JE: Nitrogen Requirement of the Kitten. Am J Vet Res 41:1646-1649, 1980.
2. Baker DH: Some Essentials of Kitten Diet. Petfood Ind 22(2):20-34, 1980.
3. Burger IH, Blaza SE, Kendall PT: The Protein Requirement of Adult Cats. Proc Nutr Soc 40:102A, 1981.
4. Dickinson CD, Scott PP: Nutrition of the Cat 2. Protein Requirements for Growth of Weanling Kittens and Young Cats Maintained on a Mixed Diet. Br J Nutr 10:311-316, 1956.
5. Duncan DB: Multiple Range and Multiple F Tests. Biometrics 11:1-42, 1955.
6. Greaves JP, Scott PP: Nutrition of the Cat 3. Protein Requirements for Nitrogen Equilibrium in Adult Cats Maintained on a Mixed Diet. Br J Nutr 14:361-369, 1960.
7. Jansen GR, Deuth MA, Ward GM, Johnson DE: Protein Quality Studies in Growing Kittens. Nutr Rep Int 11:525-536, 1975.
8. Miller SA, Allison JB: The Dietary Nitrogen Requirements of the Cat. J Nutr 64:493-501, 1958.
9. National Research Council: Nutrient Requirements of Cats. Washington DC, National Academy of Sciences, 1978, p 25.
10. Rogers QR, Morris JG: Do Cats Really Need More Protein? J Small Anim Pract 23:521-532, 1982.

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