Captive rearing diet of the New Zealand shore plover

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1. Introduction

Captive shore plover at Mt Bruce National Wildlife Centre (Masterton) have been fed a diet that has been shown to be a well-balanced ration for this insectivore. The aim of this study was to describe the nutrient content and nutrient digestibility of the current diet fed to captive NZ shore plover. A further aim was to determine the possibility of using acid-insoluble ash (AIA) as an indigestible marker to measure digestibility of birds in the wild.

2. Material and methods

The animal experimentation was conducted at Mt. Bruce National Wildlife Centre (Masterton) from 4 to 8 May 1999. Chemical analyses of the diet and faeces as well as calculation of the results were conducted by Massey University.

Six shore plover birds were randomly selected and assigned to one of two brooders, with brooder 1 containing birds c60719, c60718, c60701 and brooder 2 birds c60702, c60722, c60723. In each brooder there were two males and one female, all adults of approximately the same age. Weights of these birds at the time of the study are unknown but weights of the birds taken in the previous five months were: brooder 1: 57 g, 56 g, unknown; and brooder 2: 71 g, 54 g and 74 g.

The brooders were made from a fibreglass tub (0.70 m width x 1.60 m length x 0.65 depth) with the floor lined with two layers of black plastic sheets. Lights were on during the day and turned off at night, with no heating in the room. The birds had *ad libitum* access to fresh water. A mixed diet was provided *ad libitum* at 8.30 am each and 20 mealworms were placed in each brooder daily. Table 1 presents the diet eaten by the six birds. Faeces, collected on the weighed black plastic sheets, were collected twice a day at 4.30 pm and 8.30 am. Faecal collection involved removing the preweighed top black plastic sheet from the brooder, weighing the sheet and scraping the faeces off into a plastic bag (care was taken not to include any spilled food). At 8.30 am each day birds were moved to a new clean brooder. Daily food intakes and faeces outputs were recorded. Samples of the mixed diet, mealworms and faeces were frozen and transported to Massey University for analyses.

The diet eaten by the shore plover (mixed diet + mealworms) and the faeces (bulked over the 5 day collection period and over the two brooders) were freeze-dried and analysed for dry matter, crude protein, lipids, amino acids, fatty acids, ash and acid insoluble ash. The diet was also analysed for minerals. Dry matter was determined by oven drying at 105 °C while ash was determined by heating the sample to 550 °C for 16 h. Crude protein was determined by multiplying nitrogen by 6.25, with nitrogen determined by the Kjel-

dahl technique. Lipid was analysed using petroleum ether extraction, and amino acids were determined by high-pressure liquid chromatography. Fatty acids were analysed using gas chromatography. Mineral determination was carried out by plasma emission spectrophotometry. Acid-insoluble ash in samples was determined by boiling in HCl for 30 min, filtering through ashless filter paper, washing with boiling water then ashing at 650 °C for 6 h.

3. Results

The birds consumed all the mealworms provided, and the average amount of mixed diet eaten per day, by a brooder of 3 birds, was approximately 70 g (Table 2). Based on information supplied, a total of 20 mealworms (2.14 g) were given to the birds in each brooder. The amount of daily diet eaten by the birds in each brooder is presented in Table 2.

The nutritional composition of the diet consumed by the shore plover birds is presented in Tables 3-6. The gross nutrient composition is presented in Table 3, the dietary amino acid profile in Table 4, the dietary fatty acid profile in Table 5 and the mineral content in Table 6. The concentration of a number of minerals (including selenium) was below the detection limits of the machine. Selenium in the diet was <77.0 FIg/kg.

The average daily amount of faeces produced by the birds in the two brooders is shown in Table 7. Of the total amount of faeces produced, an average of 59% was recovered from the plastic sheets. The birds in both brooders produced similar amounts of faeces (approximately 27 g).

Tables 8-10 present the apparent faecal digestibility of gross nutrients (Table 8), amino acids (Table 9) and fatty acids (Table 10).

The lipid component of the diet (18% on a dry matter basis) is highly digestible,with 81% of the crude fat being digested. Crude protein made up 40% of the diet, with approximately 76% digested (based on amino acid nitrogen digestibility). Organic matter was less digestible, making up 93% of the diet but with only 64% being digested. The majority of amino acids have high digestibility values with lower digestibility values found for glycine and cysteine. The majority of the fatty acids have high digestibility values with the apparent faecal digestibility ranging from 60 to 92%.

The recovery of acid-insoluble ash (AIA) was 122%, i.e. the birds excreted 22% more AIA than they consumed through the diet.

4. Discussion

The aim of the present study was to describe the composition in terms of nutrient content and digestibility of nutrients of the diet fed to NZ shore plover held at Mt Bruce National Wildlife Centre (Masterton). For this reason, a semi-controlled experiment was conducted to obtain digestibility values of individual nutrients. In general the results indicate that the protein (amino acid nitrogen), lipid and fatty acid fractions of the diet are relatively highly digestible (in general >75%). Lower digestibility values were obtained for dry matter, organic matter, carbohydrates, glycine, cysteine and the minerals.

Birds excrete high levels of uric acid, which is mixed with the faecal material during excretion. This results in an incorrect estimate for the digestibility of crude protein, so this was not attempted. The reason for the low digestibility of dry matter and organic matter is related to the carbohydrate fraction of the diet. Shore plover apparently digest the protein and lipid fraction to a high degree but only digest the carbohydrate fraction for 40%. This can be expected from insectivores, as they normally do not ingest a diet rich in carbohydrates in the wild - insects mainly consist of protein, lipids and chitin.

The low apparent digestibility of cysteine can be explained by the presence of feathers in the faeces, some of which remained in the samples although care was taken to remove the majority of them. Feathers are high in cysteine. The low apparent faecal digestibility of glycine is an artefact of the presence of uric acid in the faecal samples, as uric acid is spontaneously converted to glycine in faeces.

The diet has a good balance and content of most nutrients. The ratio of calcium to phosphorus (1.1:1) is low, and during the breeding season it should be increased (approximately 5:1) by addition of more calcium to the diet to allow egg shell formation. The availability of mineral in the diet could not be determined as the urine is excreted with the faeces. Measurement of the mineral content of the faeces therefore allows the determination of mineral retention instead of mineral availability. The concentration of selenium in the diet (<77 pg/kg dry matter) was below the detection limit of the instrument. Normal levels of selenium in the diets for poultry and other production animals are 0.1 mg/kg dry matter and this suggests that the diet is likely to be deficient in selenium.

The acid-insoluble ash (AIA) recovery was 22% more than the birds actually ate. This is probably due to the low AIA content of the diet, which may have been underestimated as a result.

5. Conclusions

The diet fed to NZ shore plover at Mt Bruce National Wildlife Centre is highly digestible and provides a good balance of nutrients to the birds. Only the

carbohydrate fraction appears to be poorly digested. Although the calcium to phosphorus ratio is adequate for adult non-breeding birds, during the breeding season this ratio should be increased. The diet is likely to be marginal or even deficient in selenium. The pattern of nutrient digestion of shore plover is consistent with that expected of an insectivore.

Acid-insoluble ash has potential as an indigestible marker to measure digestibility of birds in the wild if the diet contains a sufficiently high level of it. Although the recovery of AIA was too high in the present study, the measured digestibilities of nutrients were only moderately affected.

6. Recommendations

- Increase the selenium levels of the diet. Add 0.1 mg/kg diet dry matter.
- Increase the calcium levels of the diet during the breeding season. Add 50 mg/g diet dry matter.
- The diet developed at Mt Bruce National Wildlife Centre for the insectivorous NZ shore plover should be evaluated as a general diet for other endangered insectivores such as the kiwi.

7. Disclaimer

The Monogastric Research Centre, Massey University, has taken every care to ensure that the contents of this report provide a correct reflection of its current understanding of these results and that the information presented is accurate. The Monogastric Research Centre cannot, however, accept responsibility for any inaccuracies or errors in the information presented. Similarly, no responsibility is accepted for any interpretations made from the information provided.

Appendix 1. Tables of results

Table 1. Diet formulation eaten by captive NZ shore plover

Ingredient	Amount (%)
Friskies Go-cat[a]	20
Oxheart mince	17
Wambaroo insectivore mix[b]	7
Water	39
Mealworms[c]	17

[a]Go-Cat (dry cat food) Chicken, Beef, Calcium and Vegetable flavour, Friskies Pet Care, 1 Broadway, Newmarket, Auckland.
[b]Wambaroo Food Products, Mount Barker Road, Glen Osmond, S.A. 5064,Australia.
[c]Mealworms (Tenebrio molitor) Biosuppliers live insects, 201 Eskdale Rd, Birkenhead, Auckland.

Table 2. Amount of mixed diet and daily diet eaten (in grams) by captive NZ shore plover over the 5-day collection period.

	Mixed diet		Daily diet[a]	
Day	Brooder 1	Brooder 2	Brooder 1	Brooder 2
Tuesday	53.3	55.7	55.4	57.8
Wednesday	65.7	60.9	67.8	63.0
Thursday	70.7	73.7	72.8	75.8
Friday	62.7	77	64.8	79.1
Saturday	84.4	92.8	86.5	94.9
Average daily intake	67.4	72.0	69.5	74.1

[a]Daily diet equals mixed diet plus mealworms.

Table 3. Gross nutrient composition (%) of the daily diet eaten by captive NZ shore plover.

Dry matter	33.2
On a dry matter basis:	
Crude protein	39.9
Lipid	18.6
Carbohydrate[a]	34.5
Ash	7.0

[a]Calculated (100 - protein - lipid - ash)

Table 4. Amino acid profile (g/1008) of the daily diet eaten by captive NZ shore plover.

Aspartic Acid	3.4	Leucine	3.5
Threonine	1.5	Tyrosine	1.3
Serine	1.7	Phenylalanine	2.3
Glutamic Acid	5.4	Histidine	1.0
Proline	1.8	Lysine	2.1
Glycine	2.2	Arginine	2.2
Alanine	2.4	Cysteine	0.5
Valine	2.0	Methionine	1.0
Isoleucine	1.6		

Table 5. Fatty acid profile (mg/g) of the daily diet eaten by captive NZ shore plover.

Myristic acid (C14:0)	4.3
Palmitic acid (C16:0)	19.2
Palmitoleic acid (C16:1)	2.1
Margaric acid (C17:0)	trace
Stearic acid (C18:0)	31.9
Oleic acid (C18:1)	56.4
Linoleic acid (C18:2)	17.0
Linolenic acid (C18:3)	2.1
Arachidonic acid (C20:4)	1.1
Total UFA'	55.4
Total SFA*	78.8

'UFA = unsaturated fatty acids
*SFA = saturated fatty acids

Table 6. Mineral content of the daily diet eaten by captive NZ shore plover.

	Amount (mg/g)		Amount u g/g)
Calcium (Ca)	12.1	Zinc (Zn)	110.0
Phosphorous (P)	11.3	Manganese (Mn)	32.3
Potassium (K)	8.8	Copper (Cu)	30.9
Sulphur (S)	4.1		
Magnesium (Mg)	1.4		
Iron (Fe)	0.4		

Table 7. Amount of faeces (g) produced by the captive NZ shore plover over the 5-day collection period.

	Brooder 1	Brooder 2
Tuesday	13.1	18.6
Wednesday	31.4	27.6
Thursday	32.0	27.7
Friday	28.0	34.1
Saturday	31.5	29.5
Average daily faeces	27.2	27.5

Table 8. Apparent faecal gross nutrient digestibility (%) of the diet consumed by captive NZ shore plover.

Dry matter	61
Organic matter	64
Lipid	81
Carbohydrate'	40
Amino acid nitrogen	76

'Calculated by difference.

Table 9. Apparent faecal digestibility (%) of amino acids of the diet consumed by captive NZ shore plover.

Aspartic Acid	78	Leucine	80
Threonine	78	Tyrosine	80
Serine	75	Phenylalanine	81
Glutamic Acid	81	Histidine	82
Proline	76	Lysine	81
Glycine	37	Arginine	83
Alanine	76	Cysteine	64
Valine	77	Methionine	81
Isoleucine	79		

Table 10. Apparent faecal digestibility (%) of fatty acids in the diet consumed by captive NZ shore plover

Myristic acid (C14:0)	90
Palmitic acid (C16:0)	60
Palmitoleic acid (C16:1)	80
Margaric acid (C17:0)	-
Stearic acid (C18:0)	71
Oleic acid (C18.1)	85
Linoleic acid (C18:2)	88
Linolenic acid (18.3)	80
Arachidonic acid (20:4)	92

Appendix 2. Diet formulation method for NZ shore plover

Ingredients

- Friskies Go-Cat (dry cat food): Chicken, beef, calcium and vegetable flavour. *Friskies Pet Care, 1 Broadway, Newmarket, Auckland*
- Trimmed oxheart mince
- Wambaroo insectivore rearing mix (see Appendix 3 for analysis) from *Wambaroo Food Products, Mount Barker Road, Glen Osmond, S.A. 5064, Australia*
- Mealworms *(Tenebrio molitor). Biosuppliers live insects (Telephone/ Fax 09 4182 352)*
- Water

Part 1: Go-Cat mixture

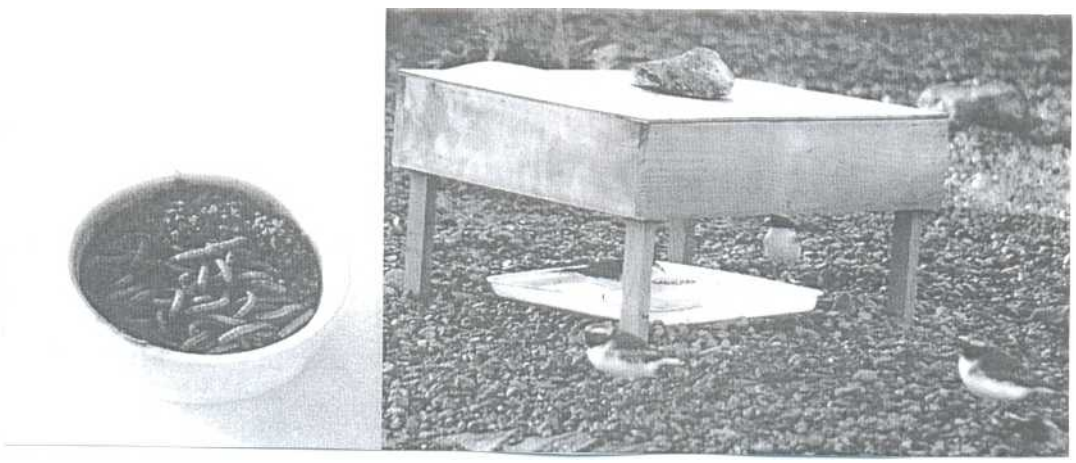
1. Blend 450 g Friskies Go-Cat in food processor until finely ground.
2. Mix with 350 ml water and leave to soak overnight.

Part 2: Oxheart mix

1. Mix 500 g trimmed oxheart mince with 200 g Wambaroo insectivore rearing mix.
2. Add 700 ml water and mix.

Presentation

Using a ceramic dish, place 35 g Go-Cat mixture in one side of the dish. Place 45 g of oxheart mix in the other side of the dish. When feeding birds, place mealworms on top of the dish (photo below left). Place dish in plastic tray filled with salty water under a wooden cover (photo below right).



Appendix 3. Guaranteed analysis of Wambaroo Insectivore Mix (from packaging)

	Min	Max
Crude protein	52%	
Crude fat		12%
Crude fibre		5%
Calcium (Ca)	1.3%	1.9%
Phosphorous (P)	1.0%	1.5%
Salt (NaCI)	0.5%	0.8%
Fluorine (F)		1 mg/kg
Vitamin A	6 mg/kg	
Vitamin D3	100 ug/kg	
Vitamin B2	8 mg/kg	
Magnesium (Mg)	800 mg/kg	
Ferrous Iron (Fe++)	80 mg/kg	
Zinc (Zn)	20 mg/kg	
Manganese (Mn)	30 mg/kg	
Copper (Cu)	2 mg/kg	
Iodine (I)	500 ug/kg	
Selenium (Se)	100 ug/kg	