PROCEEDINGS OF THE NUTRITION SOCIETY

ABSTRACTS OF COMMUNICATIONS

A joint meeting of the Nutrition Society, the Royal Zoological Society of Scotland and the British Federation of Zoos was held at Edinburgh Zoo, Murrayfield, Edinburgh on Friday–Sunday, 16–18 May 1997, when the following papers were presented.

All abstracts are prepared as camera-ready material by the authors.

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Do the energy intakes of adult budgerigars (*Melopsittacus undulatus*) and canaries (*Serinus canarius*) change with age? By E. J. TAYLOR, R. OBRA, V. KITCHENER and C. REED, *WALTHAM Centre for Pet Nutrition, Waltham-on-the-Wolds, Melton Mowbray, LE14 4RT*

In many animals age-related changes in body composition and activity levels drive a decline in energy requirements with increasing age. Little is known about the impact of age on energy requirements in exotic bird species. The present study was carried out to compare the predicted metabolisable energy (PME) intakes of a group of old and a group of young canaries and a group of old and a group of young budgerigars.

Thirty two adult canaries were allocated to group 1 (birds < 4 years, *n* 20) or group 2 (birds > 5 years, *n* 12). The birds were housed in pairs and maintained on a standard seed mix for a 2-week acclimatization period. Following this, daily food intakes were measured for a 2-week period. Thus mean daily food intakes per pair of birds were calculated. Thirty two adult budgerigars were allocated to group 1 (birds < 5 years, *n* = 16) or group 2 (birds > 6 years, *n* 16). The birds were housed in groups of four and then a protocol identical to the canary protocol was carried out. Mean daily food intakes per cage of four birds were calculated. The PME values of the diets were calculated using the National Research Council (1994) calculation for cereals (protein x 12.9 + fat x 32.1 + carbohydrate x 15.74).

The PME of the diet fed to the canaries was calculated as 1.52 MJ/100 g and that of diet fed to the budgerigars was 1.31 MJ/100 g. The food intakes of the adult canaries were comparable with those previously reported (Taylor *et al.* 1994) as were those for the budgerigars (Earle & Clarke, 1991). The canaries in our aviaries have a typical life expectancy of about 6 years, therefore birds older than 5 years are considered old. Budgerigars tend to live longer, typically until about 10 years of age. Mean body weights were not significantly different between the two groups of canaries or the two groups of budgerigars. There was no apparent effect of age on the food or energy intakes of the birds in this study. These results suggest that food and energy requirements do not decline as adult budgerigars and canaries age.

Species	Canaries				Budgerigars			
Group	1		2		1		2	
	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*
Body wt (g)	19.85	1.38	20.88	1.41	60.7	10.17	60.05	13.4
Food intake (g/d)	4.94	1.12	5.35	1.53	6.22	0.28	7.64	0.33
PME intake (kJ/g body wt per d)	3.78	0.66	3.98	1.36	1.33	0.27	1.65	0.32

Earle, K. E. & Clarke, N. R. (1991). Journal of Nutrition **121**, S186-S192.

National Research Council (1994). Nutrient Requirements of Poultry. 9th ed. Washington DC: National Academy Press.

Taylor, E. J., Nott, H. M. R. & Earle, K. E. (1994). Journal of Nutrition **124**, 2636S-2637S.

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The proximate nutrient, gross energy and mineral composition of some seeds commonly fed to small psittacines and passerines. By E. J. TAYLOR, *WALTHAM Centre for Pet Nutrition, Waltham- on-the-Wolds, Melton Mowbray, LE14 4RT*

Granivorous avian species are often maintained on seed-based diets comprising a variety of seed types. Small psittacines such as the budgerigar *(Melopsittacus undulatus)* and passerines such as the canary *(Serinus canarius)* are limited to small seeds which they are able to handle. These typically include millet (*Panicum milioceum*), rapeseed (*Brassica rapa*), canary seed (*Phalaris canariensis*), groats (*Avena sativa*) and niger (*Guizotia abyssinica*). The current paper presents some typical nutrient analyses for these seed types.

Duplicate samples of each seed type were obtained from local pet stores and de-husked by hand. The kernels were analysed for moisture, crude protein (CP), fat, ash and minerals. Moisture and ash were determined by thermogravimetric analysis. CP was determined by Kjeldahl (using 6.25 to convert from total N to CP). Minerals were determined using flame atomic absorption spectrophotometry. Nitrogen Free Extract (NFE) was determined by difference and gross energy (GE) content of the kernels was measured by bomb calorimetry.

The analytical results for each seed type are presented in the Table. The CP level for all seeds was adequate to meet the minimum requirement for adult budgerigars, reported to be 100 g/kg diet (Drepper *et al.* 1988). Some seeds, e.g. millet, may have inadequate protein levels to support growth and development. Ca levels were probably insufficient in all the seeds, except rapeseed, to support breeding and growth. The Ca : P ratio was also low in all the seeds. Based on the established nutrient requirements of poultry (National Research Council, 1994), unsupplemented all-seed diets are unlikely to be nutritionally complete for birds and these diets will therefore require mineral supplementation.

Seed Type	White Millet		Rapeseed		Canary Seed		Groats		Niger	
	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*
Husk (g/kg)	137.6	50.53	191.3	30.21	212.9	0.68	-		182.5	0.95
Kernel (g/kg)	862.3	50.54	808.7	30.22	778.3	0.68	-		817.5	0.91
GE (MJ/kg)	16.4	0.82	24.8	0.96	18.4	0.45	17.2	0.4	22.5	1.01
Moisture (g/kg)	102.6	11.1	61.1	2.76	97.5	4.52	109	6.17	51	1.03
CP (g/kg)	123.4	8.74	209.0	10.02	170.3	18.11	127.1	5.41	231.5	26.55
Fat (g/kg)	47.7	2.83	47.5	23.46	96.4	32.36	83.2	31.44	343.4	9.58
Ash (g/kg)	21.2	5.56	42.3	0.93	50.5	1.16	17.6	1.23	48.5	1.53
NFE (g/kg)	705.3	16.44	212.9	8.61	585.7	21.9	663.4	17.55	299.3	24.91
Ca (mg/kg)	136.8	6.65	4200.1	114.84	390.4	31.51	469.67	29.67	3526.3	126.35
P (mg/kg)	2585.2	91.39	7321.8	130.06	4240.9	127.3	3757.6	342.35	7454	208.9
Mg (mg/kg)	1107.7	32.85	1957.7	42.3	1406.5	30.95	1150.7	49.3	3310.2	589.81
Mn (mg/kg)	9.8	0.09	27.6	0.19	56.4	0.31	37.4	3.42	44.1	17.09
Fe (mg/kg)	45.1	4.96	62.9	3.31	57.7	2.73	43.3	6.7	150.1	25.32
K (mg/kg)	2126.9	18.65	6554.6	108.22	2609.1	7.85	3274.1	74.14	8103.7	1096.3
Na (mg/kg)	62.3	11.01	48.5	10.09	68.7	3.41	54.1	14.14	78.2	8.16
Cu (mg/kg)	5.3	0.62	3.0	0.08	6.7	0.22	4.0	0.04	10.2	2.16
Zn (mg/kg)	21.9	0.21	23.7	0.21	30.1	0.28	23.2	1.83	35.2	1.84

Drepper, K., Menke, K.H., Schulz, G. & Wachter-Vormann, W. (1988). Kleintierpraxis **33**, 57-62.

National Research Council (1994). Nutrient Requirements of Poultry. 9th ed. Washington DC: National Academy Press.

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A study of the diet and food preferences of six captive lowland gorillas (*Gorilla gorilla gorilla*) with reference to breeding success. By ANGELIQUE F. TODD and BARRY STEVENS-WOOD,
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Howletts and Port Lympne Zoo Parks in Kent, England, house the largest and most successful breeding colony of western lowland gorillas in the world (n=51, Halliday, 1996). As these zoos have been so successful in their breeding of gorillas, identification of those husbandry practices that might contribute to such propagation would be useful. The present study examined dietary variation and patterns of food choice, as these variables may well be crucial in the enhancement of breeding success.

The published zoo diet includes over 134 different foods annually, which was found to be diverse compared with other establishments holding gorillas. Foods varied daily, seasonally and in their distribution within the enclosure. The diversity available was considered stimulating in terms of such factors as taste, texture and colour and in the different modes of preparation to obtain the edible parts. This regimen mimics the variety of foods encountered in the wild, some studies recording up to and over 200 foods (Tutin & Fernandez, 1993; Nishihara, 1995). It was speculated that the equal proportions of fruit and fibrous food types in the diet was a reasonable balance in view of the seasonal variations and population differences seen in the wild. Lowland gorillas have been found to be more frugivorous than their mountain counterparts, but reliance on certain staple fibrous foods is evident especially when fruit is scarce (Tutin & Fernandez, 1993; Nishihara, 1995).

Degrees of selectivity were examined by recording the sequential choice of foods. Trials resulted in a list of twenty-seven foods that were preferred at least once, including seventeen fruits, eight vegetables and two miscellaneous foods; only nine of these foods were available to all animals. Several methods were used to analyse ranks in an attempt to overcome the problems associated with calculating accurate measures of preference in a multi-choice situation. Mean ranks (see table), a hierarchical matrix, and a preference index (a ratio of inverse rank and the relative availability of foods), all essentially produced the same results which may question the use of more complex methods to investigate preference.

Overall fruits were favoured over vegetables; differences in the detail of the rank order between individuals were attributed to differences in sex, age and history. Most highly favoured foods were only available on an occasional basis and thus the effect of novelty may have been important.

Animal (No. trials)	SB1 (n=7)		SB2 (n=1)		AF1 (n=2)		AF2 (n=3)		AF3 (n=8)		BB (n=10)		JF (n=6)	
Mean Rank	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Grapes	3.5	2.0	1.0	2.0	2.0	2.0	7.0	2.0	4.5	2.0	1.0	2.0	2.5	2.0
Pear	3.3	1.3	5.0	1.3	3.0	1.3	7.0	1.3	3.4	1.3	4.8	1.3	5.2	1.3
Apple	3.0	1.7	2.0	1.7	4.0	1.7	2.0	1.7	5.6	1.7	4.4	1.7	7.0	1.7
Orange	4.3	0.7	4.0	0.7	4.0	0.7	4.7	0.7	5.7	0.7	5.1	0.7	5.5	0.7
Lettuce	6.9	0.9	7.0	0.9	7.0	0.9	6.0	0.9	4.8	0.9	5.0	0.9	6.0	0.9
Pepper	5.8	0.7	7.0	0.7	7.0	0.7	5.3	0.7	6.3	0.7	6.5	0.7	6.6	0.7
Tomato	5.0	0.7	7.0	0.7	7.0	0.7	6.3	0.7	6.3	0.7	7.0	0.7	6.3	0.7
Carrots	5.9	0.7	7.0	0.7	6.0	0.7	5.0	0.7	6.2	0.7	6.9	0.7	6.8	0.7
Cucumber	6.8	0.4	7.0	0.4	7.0	0.4	6.0	0.4	7.0	0.4	6.1	0.4	7.0	0.4

The above foods are those that were available to all animals and are ranked by overall preferences based on pooled data.
1.0 to 6.0 = first to sixth choice, 7.0 = chosen seventh or thereafter.
SB = silverback, BB= blackback (immature male), AF= adult female, JF= juvenile female; numbers represent individual.

Nutritional analysis found that preferred foods provided significantly higher levels of sugar and energy ($P<0.05$). It was suggested that the feeding of fruit items in the morning and more freshly cut forage throughout the day would be more in keeping with natural diurnal patterns of food choice and allow the gorillas to make more economical use of their energy resources.

The dietary variation exhibited by the management regimen at the study zoo and the pattern of food choice this allowed, were concluded to be important in stimulating natural patterns of behaviour.

Halliday, P. (1996). *Help (Friends of Howletts and Port Lympne Newsletter)* **18**, 11-12.
Nishihara, T. (1995). *Primates* **36**, 151-168.
Tutin, C.E.G. & Fernandez, M. (1993). *American Journal of Primatology* **30**, 195-211.

Nutritional balance studies with pilchards and squid in Little penguins, *Eudyptula minor*. By T. L. FRANKEL, *School of Agriculture, Faculty of Science and Technology, La Trobe University, Bundoora, Victoria, 3083, Australia*

The natural diet of the Little penguin in Victoria consists of about 73% fish and 21% cephalopods (Cullen *et al.* 1992). In preliminary experiments to determine the nutritional requirements of Little penguins, their ability to digest and utilize different types of natural prey was determined.

Two groups of five penguins were obtained from the wild at different times and housed indoors with access to a tank of water. The birds were fed, twice daily, whole West Australian pilchards (*Sardinops neopilchardus*), a mixture (120:90) of whole pilchards and squid (*Loligo spp.*) or minced pilchards in sausage casings (in order to produce a more homogeneous composition). The amount fed was adjusted to maintain constant body weight and birds were given vitamin and mineral supplements. Because the penguins drink water while swimming and because their feathers become soiled by lying down in metabolism cages, it was decided to keep feeding time and food intake constant by exploiting the necessity to hand-feed the penguins. Nutrient balance was then determined by keeping the birds in metabolism cages for separate 24 h periods, with periods of at least 24 h uncaged. Two to four 24 h collections were made for each bird and the data averaged for each bird. Proximate analysis was carried out on food and excreta.

Food ...	Pilchards				Pilchards and squid		Pilchard sausage	
Penguin Group ...	Group 1 (*n* 5)		Group 2 (*n* 4)		Group 2 (*n* 3)		Group 2 (*n* 2)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Body weight (kg)	1.134	0.12	1.183	0.068	1.167	0.038	1.144	0.054
Change in weight (g)	-8.36	8.52	8.08	9.89	-0.57	5.01	-18.5	5.5
Gross energy (GE) intake (kJ/d)	919.7	17.1	1272.7	135.5	1125.6	46.0	889.0	3.7
ME intake (kJ/d)	719.8	25.0	913.5	130.6	774.3	27.5	672.8	7.5
ME intake (kJ/kg per d)	645.6	58.5	778.1	132.77	664.9	45.4	590.3	22.5
Energy metabolizability	0.783	0.02	0.717	0.030	0.689	0.042	0.757	0.005
N intake (g/d)	4.40	0.08	5.86	0.62	5.97	0.77	3.82	0.02
N gain or loss (g)	0.66	0.3	0.24	0.46	0.89	1.13	0.12	0.09
Fat intake (g/d)	12.67	0.23	22.4	2.39	14.72	0.14	5.51	0.02
Fat digestibility	0.852	0.018	0.917	0.02	0.886	0.042	0.799	0.048
Ash intake (g/d)	5.34	0.10	8.17	0.86	5.92	0.16	6.69	0.03
Ash gain or loss (g)	0.04	0.42	-0.32	0.21	-0.63	0.18	0.23	0.01

Values for proximate analyses for fish and squid were similar to published values (e.g. Paul & Southgate, 1978), those for sausages were slightly lower than whole pilchards. Calculated by difference, fat digestibility was lower in squid (0.314 (SD 0.35)) than pilchards and energy metabolizability for squid was slightly lower (0.628 (SD 0.204) v. 0.73 (SD 1.5)) than that determined by Gales (1989) who fed a diet entirely of squid and kept birds continuously in metabolism cages for 5 d: the difference may have been due to determining metabolizable energy (ME) of squid in the mixed diet by difference or to giving birds a greater GE intake/d than Gales (1989) who fed approximately 800 kJ GE /d. Feeding minced pilchards at a lower energy intake than whole fish resulted in higher energy metabolizability. Energy and protein balance was maintained with both species of prey and ME intake/kg was higher than that reported by Gales (1989).

Cullen, J.M., Montague, T.L. & Hull, C. (1992). *Emu* **91**, 318-341.
Gales, R. (1989). *Physiological Zoology* **62**, 147-169.
Paul, A.A. & Southgate, D.A.T. (1978). *McCance and Widdowson's The Composition of Foods*, 4th ed. London: H.M. Stationary Office.

Frugivorous primate diets in Kibale Forest, Uganda. By NANCY LOU CONKLIN-BRITTAIN[1], RICHARD W. WRANGHAM[1], and KEVIN D. HUNT[2], [1]*Department of Anthropology, Harvard University, Cambridge, MA 02138, USA*, [2]*Department of Anthropology, Indiana University, Bloomington, IN 47405, USA*

The formulation of captive diets for wild animals is often hampered by the lack of adequate wild diet information. This report presents the first complete nutritional evaluation of wild diets consumed by free-ranging primates over the course of 12 months (July 1992-June 1993). The sympatric species studied were chimpanzees (*Pan troglodytes*), redtail monkeys (*Cercopithecus ascanius*), blue monkeys (*C. mitis*), and grey-cheeked mangabeys (*Cercocebus albigena*) in Kibale Forest, Uganda. We recorded timed feeding observations and collected plant foods according to plant part and maturity seen eaten. Standard nutritional analyses were performed (Conklin & Wrangham, 1994). We analysed 408 samples of 194 plant items, representing 94.3% of plant-feeding time across primate species. ANOVA and Scheffé's multiple contrasts were used to determine differences among species.

		Chemical fractions consumed (g/kg diet dry matter)*								
		Lipid	CP	SS	TNC	NDF	ADF	HC	Cs	Ls
Chimpanzee:	Mean	24.6	94.8^{a}	149.4^{a}	387.9^{a}	335.9	195.7	137.2	117.8	78.0
	SE	6.4	8.7	23.9	22.4	12.9	16.8	12.8	13.6	6.8
Mangabey:	Mean	36.8	160.0^{b}	100.5^{b}	339.7^{b}	329.5	204.1	122.8	121.4	82.8
	SE	4.1	4.3	4.0	9.6	8.3	5.6	3.8	3.4	3.5
Blue:	Mean	30.9	169.4^{b}	100.1^{b}	366.5^{ab}	328.0	200.3	125.9	119.3	81.1
	SE	3.4	3.8	4.5	5.8	6.6	4.5	3.9	3.5	2.7
Redtail:	Mean	35.2	171.0^{b}	107.4^{b}	370.9^{ab}	315.2	193.3	120.8	112.6	80.8
	SE	4.8	3.3	5.3	8.1	7.2	5.8	2.4	3.4	2.8

CP, crude protein; SS, simple sugars; TNC, total non-structural carbohydrates; NDF, neutral-detergent fibre; ADF, acid-detergent fibre; HC, hemicellulose; Cs, cellulose; Ls, lignin.

^{a,b} Mean values within a column not sharing a common superscript letter were significantly different ($P < 0.05$).

* Each mean calculated from twelve monthly weighted averages per chemical fraction. The weighting factor was percentage of time spent feeding on a given item.

All primate groups appeared healthy. The chimpanzee diet contained only about half the protein found in monkey diets. However, the chimpanzee value was similar to human protein requirements (Oftedal, 1991). Lipid levels in the diet were low for all four species.

Contrary to expectations and despite large body size differences (chimpanzee 40-50 kg; mangabey 7-10.5 kg; blue monkey 3-6 kg; redtail monkey 3-4 kg) all of these species consumed a diet containing the same proportion of all the fibre fractions. The NDF level consumed by chimpanzees was consistent with fibre levels used in feeding trials (Milton & Demment, 1989), which they demonstrated a high capacity to digest. No feeding trials have been performed with these monkey species, but Maisels (1993) has shown that they have passage times more similar to folivorous howler monkeys than to the other frugivorous primates she reviewed.

The significance and consequences of these results deserve further investigation but meanwhile they provide realistic target values for diet formulation.

Conklin, N.L. & Wrangham, R.W. (1994). *Biochemical Systematics and Ecology* **22**, 137-151.

Maisels, F. (1993). *Folia Primatologica* **61**, 35-37.

Milton, K. & Demment, M.W. (1988). *Journal of Nutrition* **118**, 1082-1088.

Oftedal, O.T. (1991). *Philosophical Transactions of the Royal Society, London* series B, **334**, 161-170.

Use of n-alkanes as markers for the study of digestive strategies in captive giraffes (*Giraffa camelopardalis*). By J.-M. HATT[1], R.W. MAYES[2] and M. LECHNER-DOLL[3], [1]*Faculty of Veterinary Medicine, University of Zurich, Switzerland,* [2]*Macaulay Land Use Research Institute, Aberdeen AB15 8QH,* [3]*Institute for Zoo Biology and Wildlife Research, Berlin, Germany*

Different plants contain differing mixtures of predominantly odd-chain n-alkanes, which, with their high recovery in faeces, allows their use as markers to estimate the composition and digestibility of mixed herbivore diets (Dove & Mayes, 1991). Concurrent oral dosing with an even-chain alkane, similar in chain length to dietary alkanes, enables intake estimates to be made (Mayes *et al.*, 1986).

The efficacy of using n-alkanes to estimate diet composition, intake and digestibility in captive giraffes (*Giraffa camelopardalis*) was tested with six animals at Regent's Park, London. Three subadult animals were maintained as a group, and three adults were kept as a group during the day, but housed and fed separately at night. The normal diet consisted of clover hay, cattle pellets, a mix of crushed oats and wheat bran and vitamin E cubes, together with cabbage and fresh browse, mainly evergreen oak, offered daily. In addition, potatoes, carrots and bananas were given three times a week. For a 3-week period, even-chain alkane markers (C_{28}, C_{32} and C_{36}) were administered (1mg/d/kg body weight, each alkane) by giving each animal a fixed daily quantity of cattle pellets, labelled with the alkanes (3000mg/kg DM, each alkane). Feed and faeces samples were collected once daily and freeze-dried and milled, prior to analysis for alkanes by GC.

To allow for changes in faecal recovery with alkane chain length, which have previously been observed in domestic ruminants (Dove & Mayes, 1991), corrections were made using alkane recovery factors obtained for sheep by Mayes *et al.* (1986). The concentrations of C_{28}, C_{32} and C_{36} in giraffe faeces, relative to their respective administration rates, confirmed the validity of using sheep recovery factors. Using an iterative method, diet composition was calculated as that which produced the minimal discrepancy sum-of-squares between calculated and actual faecal alkane concentrations. Intakes of DM were calculated according to the equation of Mayes *et al.* (1986) from the dose rate of C_{32} alkane and respective C_{32} and C_{33} concentrations in the faeces and calculated mixed diets. Comparisons of calculated with actual intakes was possible only for the adult animals yet variations in faecal alkane patterns between the subadult individuals suggested large differences their dietary composition. Results from the adults indicated that intake of cabbage, browse and cattle pellet could accurately be estimated with the alkane method, but for the oat/wheat mix and clover hay there were large differences between directly-measured intakes and those obtained using the alkane method. These discrepancies may have been due to diurnal variation in faecal C_{33}:C_{32} concentration ratios, or to errors in diet composition estimates resulting from the relatively low alkane concentrations of the oat/wheat mix. No attempt was made to estimate intakes of potato, carrot and banana because the alkane concentrations of these feedstuffs were extremely low; in any case, on a DM basis, they comprised less than 2% of the actual diet. Total dietary DM digestibility, measured using alkane-derived intakes and faecal output (from faecal C_{36} concentrations), ranged from 0.33 to 0.77.

This study, using captive giraffes, has shown that n-alkanes have potential as markers for investigating digestive strategies in non-domestic herbivores. Further work is needed to examine the impact of more frequent dosing and sampling routines, and to examine the reliability of diet composition estimates in relation to the alkane concentrations of individual dietary components.

Dove, H. & Mayes, R.W. (1991). *Australian Journal of Agricultural Research* **42**, 913-952.

Mayes, R.W., Lamb, C.S. & Colgrove, P.M. (1986). *Journal of Agricultural Science, Cambridge* **107**, 161-170.

Research in nutrition at the Jersey Wildlife Preservation Trust. By ANNA T.C. FEISTNER, *Research Department, Jersey Wildlife Preservation Trust, Les Augrès Manor, Trinity, Jersey JE3 5BP*

The Jersey Wildlife Preservation Trust (JWPT) is an international conservation organisation working to save animals from extinction. JWPT supports research on both wild and captive animals which is likely to assist the conservation and/or well-being of the individual animal, the population from which it derives, its species, or of related taxa. Research on nutrition is carried out both as a problem-solving exercise (in relation to ill health or apparent infertility) and as part of ongoing programmes to improve animal husbandry. The aims have been to enhance nutritional quality and palatability and to stimulate natural foraging behaviour. Work on reptiles, birds and mammals has been carried out.

As JWPT is dealing with captive breeding programmes (CBP) for highly endangered species, the emphasis is on non-invasive research methods. Intake is determined by weighing and drying feed remains and analysing the diet using a software package to quantify nutritional intake. Direct observation is used to record individual intake rates and food preferences, and provides information on feeding and foraging behaviour. Faecal analyses have been undertaken and studies of gut passage time in primates have been carried out using an inert marker (Cr_2O_3) (Price, 1993; Cabré-Vert & Feistner, 1995).

Studies on St. Lucia parrots (*Amazona versicolor*) were prompted by diet-related mortality (arteriosclerosis and gout) and by dramatically reduced fertility. Both protein quality and content were increased, fat levels reduced and better mineral balance achieved (Fidgett & Robert, 1993). Since December 1992, when the changes were implemented, mortality has been significantly reduced: from ten deaths between 1989 and 1992 to only one since January 1993. Most importantly for a CBP, overall reproductive activity has increased. No surviving chicks were hatched between 1989 and 1992 and five have been produced since January 1993. Other work with the same species has indicated that individual differences between parrots are also important. For example, assessing intake by observation of items ingested indicated that captive-born females ate more than captive-born males, and that wild-born parrots consumed a greater variety of the foods presented than captive-born birds (Fa & Cavalheiro, 1997).

Work on Alaotran gentle lemurs (*Hapalemur griseus alaotrensis*) established daily intakes of forage and non-forage items, and assessed the nutritional quality of the plant parts eaten and rejected by these highly selective folivores (Fidgett, 1995; Fidgett *et al.* 1996).

The research at JWPT demonstrates that low-tech studies of diet and nutrition can make a substantial contribution to our ability to provide appropriate nutrition and species-relevant feeding methods in captive wild animals. Techniques involving observation, collection of remains and inert markers are simple to use and involve no stressful manipulation nor any great changes to the animals' normal routines - important factors when developing nutritional research methods for use with endangered species. Increased research into the nutrition of exotic species in zoological institutions is important: it increases our understanding of a species' biology and plays a practical role in improving husbandry and welfare. As our understanding of exotic animals' nutritional needs increase, our care for them improves, and we are better able to prepare them for release to the wild, should that be appropriate. Research in nutrition in zoos thus enhances their role in conservation.

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