

# ENERGY REQUIREMENTS OF NESTLING CAPE VULTURES<sup>1</sup>

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**Abstract.** A continuous feeding trial was used to determine Gross Energy Intake (GEI), Metabolizable Energy (ME) and energy Assimilation Efficiency (AE) during growth of captive (hand-reared) nestling Cape Vultures. The mean ash-free dry energy density of daily samples of excreta for the nestlings was  $14.8 \pm 0.4$  kJ/g (range 14.2–15.9 kJ/g). Nestling GEI increased from shortly after hatching to reach a maximum of  $6,443.3 \pm 388.9$  kJ/day between 80–85 days. After 85 days, GEI decreased to adult levels (range 2,734–3,639 kJ/day) between 105 days and fledging (136 days of age). AE of hand-reared nestlings ranged between 82% and 92%. Mean GEI during the period of maximum growth between 60 and 100 days was  $5,459.6 \pm 529.8$  kJ/day. If deprived of food, a 62-day old nestling with a one kilogram fat reserve (about 15% of body mass) would theoretically deplete this energy reserve in about eight days, if growth continued at a normal rate.

**Key words:** *Gyps coprotheres*; Cape Vulture; energy requirements; growth; fat reserves.

## INTRODUCTION

The Cape Vulture *Gyps coprotheres* is endemic to southern Africa. It is considered a vulnerable species (Brooke 1984), and the population has declined in breeding range and numbers (Boshoff and Vernon 1980, Piper et al. 1981, Mundy 1982, Brown 1985). The causes of this decline have been ascribed to poor survival rates (Piper et al. 1981), low reproductive success and a number of human related factors such as poisoning, habitat encroachment and electrocution (Mundy 1982, Brown 1985).

Cape Vultures, like their congeners elsewhere, are scavengers of large ungulate carcasses (Kruuk 1967, Houston 1974, Richardson 1980, Mundy 1982), and, in rural areas which no longer support wild ungulate herds, scavenge domestic livestock (Mundy 1982, Robertson and Boshoff 1986). The greater part of the Cape Vulture's breeding range is incorporated in such rural areas, and this change in food resource has taken place in the last two to three hundred years (Mundy 1982).

Vultures constitute a poorly studied group in bioenergetic research. Gross food intake of captive nestling White-backed Vultures *Gyps africanus* (Houston 1976, Mundy 1982), Rüppell's Griffon Vultures *G. rueppellii* (Houston 1976), adult European Griffon Vultures *Gyps fulvus* (Mendelssohn and Leshem 1983) and adult Cinnereous Vultures *Aegyptius monachus* (Hiraldo

1983) have been measured previously. Jarvis et al. (1974) calculated gross food intake of adult Cape Vultures. None of these authors analyzed food or excreta for energy content, and in most cases assumed high energy assimilation efficiency or used predictive equations to estimate energy requirements of these species (e.g., Jarvis et al. 1974, Houston 1976, Hiraldo 1983).

In this paper the energy requirements of nestling Cape Vultures are described in terms of gross energy intake, metabolizable energy and energy assimilation efficiency, as part of a broader, conservation-oriented study of growth, food requirements and food resources of this species in a rural area of southern Africa (Komen 1986).

## MATERIALS AND METHODS

The Magaliesberg escarpment in the Transvaal province of South Africa supports two breeding colonies of Cape Vultures, at Skeerpoort (25°45'S, 27°45'E) and Roberts' Farm (25°51'S, 27°18'E).

In July 1981, five known-age nestlings (age range 12 to 21 days) were removed from the Skeerpoort colony. One of these nestlings died shortly after capture, and four nestlings were hand-reared to fledging age (about 136 days of age, Komen 1986), and maintained in captivity at the De Wildt Raptor Research Centre (25°41'S, 27°56'E), situated on the northern slope of the Magaliesberg escarpment, about 22 km east of the Skeerpoort colony.

The nestlings were subjected to a continuous feeding trial from one day after capture to fledging. They were maintained indoors until they had

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partial dorsal feathering (30–40 days of age), and were then transferred outdoors for the remainder of the trial. During the feeding trial, monthly minimum temperatures were 3°–8°C during July through September and 14°–17°C during October and November. Maximum monthly temperatures were 21°–25°C during July through September and 26°–33°C during October and November.

The nestlings were fed lean meat obtained from domestic carcasses (horses, cows and donkeys) during the study. Their diet was supplemented with day-old chicks, calcium (Calsuba, Centaur Product), bone-fragments and a mineral-vitamin mixture (Beefee, Centaur Product). Owing to the length of the feeding trial (110–120 days) different types of meat were used at different stages of the trials (Table 1). All nestlings received the same type of meat on any one day of the trial. Each nestling was fed by hand to satiation, and food intake was determined by weighing meat before feeding and left-overs immediately after feeding as well as by weighing the nestlings shortly before and immediately after feeding. Nestlings were fed twice daily from day of capture to about 25 days of age. Thereafter they were fed once daily. Spilled food, casts and regurgitations were collected whenever these occurred. Regurgitations were oven-dried at 60°C to constant mass. The dry mass of a regurgitation was subtracted from the calculated dry mass of food consumed on the same day the regurgitation occurred. Casts were examined for content, and any bones or meat fragments were oven-dried at 60°C to constant mass and subtracted from the previous day's food consumption.

Five samples (100 g each) of each food-type used for a feeding trial were taken for analyses. Each food sample was oven-dried at 60°C to constant mass. Water loss was calculated by subtraction, and mean water content calculated for the five samples. The dried samples were pooled and ground to a powder. Five sub-samples of about 10 g each were removed from the overall mixed sample, and analyzed for energy density (Gallenkamp ballistic bomb calorimeter), lipid (Soxhlet method, using petroleum ether as solvent) and protein content (microKjeldahl method). For each analysis the treatment was repeated until there was less than a five percent difference between results. Inorganic content of subsamples was initially determined by ashing oven-dried samples ( $n = 20$ ; 0.5–0.8 g each) at 550°C for

eight hours (Nabel Muffle Furnace Model 2804). It was found that there was less than five percent difference between these ash values and those derived gravimetrically from ash produced during ballistic bomb calorimetry ( $n = 20$  samples), and inorganic content was subsequently determined from the latter ash samples (JK unpublished data). Carbohydrate content was estimated by subtraction, after determination of percentage protein, percentage lipid and percentage ash of dry samples.

All feces and urine (hereafter referred to as "excreta") were collected from individual birds twice daily. Daily samples of excreta for each bird were oven-dried to constant mass. They were then analyzed for energy density and inorganic content. As with the food analyses, each treatment was repeated until there was less than five percent difference between results.

The efficiency with which birds assimilate energy was determined following Gessaman (1973):

$$ME = GEI - (F + U)$$

where ME = metabolizable energy

GEI = gross energy content of food consumed

F = energy content of feces

U = energy content of urine

and Assimilation Efficiency (AE):

$$AE = (GEI - (F + U)) / GEI \times 100 [\%]$$

The assimilation and AE of inorganic constituents of food were similarly calculated.

Body composition analyses were done on carcasses of nine nestlings (estimated age range 2–62 days old, based on measures of standard wing-length, Komen 1986) recovered freshly-dead at Skeerpoort and Roberts' Farm. The carcass of one known-age hand-reared fledgling (135 days old) and three freshly-dead adults were also analyzed. The carcasses were weighted and analyzed for water, lipid, protein, inorganic content and energy density, using the techniques described previously.

## RESULTS

The organic and inorganic composition and energy density of different meat types used in the feeding trials varied considerably, as indicated by the standard deviations, expressed as percentages, of the means calculated (Table 1). Accordingly, metabolizable energy (ME) and assim-

ilation efficiency (AE) of nestlings on any one day of the trial were calculated using the composition data for the meat-type consumed on that day of the trial.

The mean ash-free dry (AFD) energy density of 140 daily samples of excreta analyzed for four nestlings, divided between 21 five-day age-classes from 15 to 129 days was  $14.8 \pm 0.4$  kJ/g AFD (range 14.2–15.9 kJ/g AFD). The mean inorganic content of these excreta samples was  $10.3 \pm 3.1\%$  ( $n = 140$ , range 5.6%–17.1%).

Energy content of the daily excreta of individual birds increased proportionally to the energy content of food consumed. Expressed as a percentage of gross energy input, the energy content of daily output of excreta of nestlings ranged between 7.9%–17.2% (mean  $13.7 \pm 2.6\%$ ,  $n = 25$ ) from 15 to 129 days of age.

Figure 1 illustrates the changes in Gross Energy Intake (GEI) and Metabolizable Energy (ME) in relation to changes in body mass during the nestling growth period. GEI increased from shortly after hatching to a maximum of  $6,443.3 \pm 388.9$  kJ/day (mean  $\pm$  SD) between 80 and 85 days of age (range of individual nestlings' five-day interval means 5,956–6,881 kJ/day). Thereafter, GEI decreased to a fledging GEI of  $2,733.9 \pm 554.8$  kJ/day. Mean GEI was  $5,459.6 \pm 529.7$  kJ/day (range of five-day interval means, 4,916–6,443.3 kJ/day) during the period of maximum growth between 60 and 100 days of age, for a

body mass range of 5.7–7.9 kg (Fig. 1). ME followed a similar pattern during growth, and was dependent on the efficiency with which nestlings were able to assimilate energy (see below). Mean ME was  $4,821.5 \pm 517.2$  kJ/day during the period of maximum growth. A slight decrease in daily GEI between 25 and 35 days of age was a result of inconsistent food consumption due to a nematode infestation in the nestlings.

An allometric equation generated from the linear regression ( $r^2 = 0.985$ ) of a log–log plot of ME on body mass is:

$$ME = 11.54 BM^{0.69} \text{kJ/day (SEE} = 0.04)$$

where ME = metabolizable energy in kJ/day,  
BM = body mass in grams,  
and SEE = standard error of the estimate.

(SEE of slope = 0.02, and SEE of intercept = 0.08). This equation may be used to predict ME for Cape Vulture nestlings between hatching and 89 days of age.

Nestling assimilation efficiency was slightly lower from hatching to 30 days of age (range 82.8% to 85.4%), than for the remainder of the growth period (range 84.3% to 92.1%). Mean total energy AE for the entire growth period was  $86.6 \pm 2.3\%$ . AE of inorganic constituents did not follow a clear trend, and mean inorganic AE during growth was  $77.5 \pm 4.95\%$  (range 67.6% to 84.3%).

TABLE 1. Water, lipid, protein, inorganic and carbohydrate content, and energy density in kJ/g (ash-free dry (AFD) and "wet") of different food-types consumed by hand-reared nestlings during the feeding trial.

Food-type	Water %	Lipid %	Protein %	Inorganic %	Carbohydrate %	Energy density kJ/g AFD	Energy density kJ/g wet
Horse 1	71.2	1.7	22.0	3.4	1.8	25.1	6.4
Horse 2	72.9	1.3	21.1	3.6	1.1	25.2	5.9
Cow 1	76.8	0.8	18.4	3.5	0.5	25.8	5.1
Cow 2	67.6	7.6	21.9	2.6	0.4	27.3	8.1
Cow 3	72.5	2.4	21.7	2.8	0.6	27.0	6.7
Cow 4	69.7	1.9	19.2	8.7	0.5	26.0	5.6
Cow 5	70.2	4.8	21.6	3.2	0.2	26.6	7.1
Cow 6	74.5	1.4	19.3	4.0	0.7	24.8	5.3
Donkey	75.6	0.9	19.2	3.3	1.0	24.7	5.2
Calf	79.5	1.7	13.1	5.1	0.6	26.7	4.1
Mean	73.1	2.5	19.8	4.0	0.7	25.9	6.0
$\pm$ SD	3.4	2.0	2.6	1.7	0.4	0.9	1.1
CV <sup>1</sup>	4.7	82.8	12.9	42.1	58.8	3.5	18.3
Day-old chicks	79.2	4.4	7.3	8.8	0.3	44.9	5.4
Calsuba	4.0	—	—	5.1	—	16.8	—
Bone-fragments	1.2	—	—	>95.0	—	—	—

<sup>1</sup> CV = coefficient of variation.

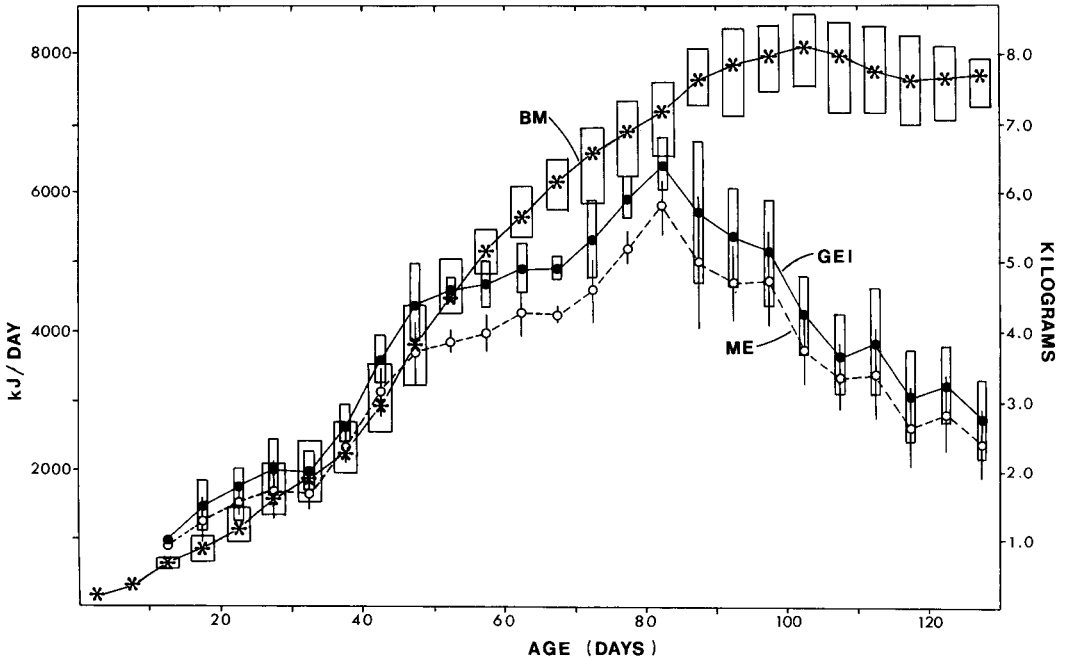


FIGURE 1. Changes in gross energy intake (GEI; kJ/day), metabolizable energy (ME; kJ/day) and body mass (BM; kilograms) of hand-reared nestlings during growth. The bars above and below GEI and BM data points represent the range in GEI and BM for each age-class, and the lines above and below the ME data points represent the range of ME. Data points represent the means of five-day age-classes.

The lipid content of wild nestlings carcasses increased with age, and accounted for as much as 996 g of lipid (15% of body mass) in one nestling (estimated 62 days of age, Table 2). Two

emaciated nestlings had relatively lower lipid content (6.0% and 4.7% of body mass), but did not appear to be dehydrated. Adult lipid content ranged between 9.5% and 15.7% of body mass,

TABLE 2. A comparison of body composition (water, lipid, protein, inorganic and carbohydrate content) and energy density (kJ/g AFD and "wet") of nine wild nestlings (including two emaciated (E) nestlings), one known-age hand-reared fledgling (FL; 135 days of age) and three wild adults (AD) recovered freshly dead. Age of wild nestlings was estimated by measures of standard wing-length on age for known-age wild-reared nestlings (Komen 1986).

Age (days)	Body mass (g)	Water %	Lipid %	Protein %	Inorganic %	Carbohydrate %	Energy density kJ/g AFD	Energy density kJ/g "wet"
2	122.5	83.7	2.2	12.8	1.0	0.2	26.8	4.3
17	865.9	71.6	11.6	14.5	1.9	0.5	30.8	8.5
19	1,076.6	69.8	14.6	13.5	1.8	0.3	30.3	9.0
26 E	1,214.0	70.7	6.0	18.2	3.7	1.4	27.1	7.6
39	2,771.8	72.6	10.4	14.1	2.2	0.7	29.6	7.9
43 E	2,402.5	70.3	4.7	20.8	2.7	1.5	27.7	7.9
48	3,770.0	66.0	14.5	17.1	2.2	0.1	29.6	9.8
51	4,385.0	64.2	17.0	16.8	2.3	—	29.6	10.3
62	6,600.4	63.5	15.1	17.8	2.1	1.3	28.6	10.1
FL	7,645.0	60.9	8.2	23.3	4.5	3.2	27.1	10.0
AD	7,586.7	54.1	11.7	28.8	4.8	0.6	27.1	11.7
AD	8,368.1	56.7	9.5	28.6	4.2	1.1	26.7	10.9
AD	8,575.4	52.6	15.7	27.4	3.9	0.3	28.5	12.8

accounting for as much as 1,346 g of lipid (Table 2). Adult protein content ( $28.3 \pm 0.8\%$ ,  $n = 3$ ) was higher than that of the hand-reared fledgling (23.3%) and the 62-day-old nestling (17.8%). This primarily reflects a difference in mass of flight musculature (mean mass of adult pectoral musculature  $1,163 \pm 64.5$  g ( $n = 7$ ) versus fledgling 1,075 g and 62-day-old nestling 352 g; Komen 1986).

## DISCUSSION

As scavengers of domestic livestock carcasses in rural areas of southern Africa, Cape Vultures are dependent on an unpredictable food resource in terms of quantity and time (Richardson 1980, Robertson and Boshoff 1986). Cape Vultures generally rear only one nestling per year and this nestling is entirely dependent on the parents for food for the duration of the nestling period of about 136 days (Mundy 1982, Komen 1986). Nestlings are generally fed once-daily by one parent, and the other parent is usually present at the nest for brooding (up to 30–40 days of age) and predator protection during the latter part of nestling period. Each parent generally forages for food once every two days (Komen 1986).

During the period of maximum growth, from 60 to 100 days of age, daily food consumption (GEI) is equivalent to  $791.0 \pm 87.8$  g meat/day, approximately double the average daily amount of meat consumed by captive adults ( $417.5 \pm 77$  g meat/day);  $GEI = 2,476.4 \pm 456.5$  kJ/day,  $n = 13$  adults; Komen 1986). Cape Vulture nestlings attained maximum daily food consumption of 1,100 g meat/day between 80 and 85 days of age. The nestlings of Rüppell's Griffon Vulture, a species of similar size, have been reported to consume a maximum of 800 g meat/day at about 60 days of age, and the relatively smaller White-backed Vulture nestlings a maximum of 450 g meat/day at 50 days of age (Houston 1978).

It is notable that, owing to crop and stomach volume, adult Cape Vultures can physically consume as much as 1,500 g meat in one sitting. Hence, they are able to provide sufficient food for the nestling during the period of maximum growth, and, except for a relatively short period of time (about 40 days), are probably able to fully satisfy their own food requirements as well (Komen 1986).

Body composition analyses suggested that nestlings reach a relatively mature stage of growth by about 60 days of age, with large fat reserves

(equivalent to adult reserves) but relatively small body protein reserves, primarily ascribed to undeveloped flight musculature at that age (Table 2, Komen 1986).

Total body lipids account for as much as 17% of body mass in nestlings, and it is ecologically meaningful to assess this lipid reserve in terms of the energy it would supply in times of food deprivation. One 62-day-old nestling carried nearly one kilogram of lipid, and would theoretically have a metabolic requirement of about 5,000 kJ/day during the period between 60 and 100 days of age. Assuming that stored lipid has an energy density of 38 kJ/g AFD (Johnston 1970), and may be completely re-absorbed for metabolism, then this lipid reserve could theoretically maintain the nestling, under normal growing conditions for  $38 \text{ kJ} \times 1,000/5,000 = 8$  days, and possibly longer if growth and metabolic rate diminish during fasting.

Similar calculations for two tern species (*Sterna* spp.) give values of between one and three days only (Ricklefs and White 1981). In the case of Leach's Storm-Petrel *Oceanodroma leucorhoa*, Ricklefs et al. (1980) calculated that the nestlings could probably rely on their lipid reserves for about one week. This species also had lipid reserves equivalent to 15% or more of body mass during growth, but it is important to note that since metabolism does not scale in direct proportion to body mass, nestlings with large bodies would use up energy reserves at a relatively slower rate than nestlings with small bodies (Lasiewski and Dawson 1967).

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