Time budget of South African cliff swallows during breeding

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The use of time by the South African cliff swallow was determined and use of energy calculated by using equations for predicting standard metabolic rate and the cost of flight. The highest daily energy expenditure was during the feeding of nestlings when 9,22 h were spent foraging. The cost of 127 kJ for building a nest is very low if it is considered that the nest is usable for a number of years.
S. Afr. J. Zool. 1986, 21: 57–59

Die benutting van tyd deur die familieswael is bepaal en die gebruik van energie is bereken deur middel van vergelykings vir basale metabolisme en vluglas. Die meeste energie word verbruik terwyl neskuikens gevoer word en tot 9,22 h is tydens hierdie periode aan die soek van kos bestee. Slegs 127 kJ is verbruik tydens nesbou en dit is baie laag indien in ag geneem word dat die nes vir 'n hele aantal jare bruikbaar is.
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The South African cliff swallow *Hirundo spilodera* breeds in dense colonies, usually on man-made structures such as concrete road bridges (Earlé 1985). Nests are built with mud and are gourd-shaped with a short entrance tunnel and a nestpad consisting of soft materials. South African cliff swallows re-occupy old nests and, if broken, repair these during the breeding season. Both sexes incubate and feed the young in about equal proportions (Earlé 1986). These swallows mostly feed on the wing. The time spent on the three activities during the South African cliff swallow breeding season were calculated from three 24-h watches at three different nests on different occasions. Nests were observed from 04h30 to 19h30 and it was assumed that the specific individuals watched spent the other 9 h during the night in the nest, which was found to be the case as the individuals only left the nests after observations started. Unless disturbed, South African cliff swallows sleep in their nests at night. Nest building was observed on 12 October 1983 at a colony where mud was collected from a temporary pool 20 m from the nest. Incubating birds were watched at another colony on 29 November 1983, while birds feeding 20-day-old nestlings were observed on 16 October 1984.

A sample of 36 adult cliff swallows was captured by mist net at a colony in October 1984 and body weight, wing span and wing length measured. To calculate the time spent flying it was assumed that the swallows only perched at the nest. Flight velocity was determined on a calm day over a 100-m course by timing 30 birds with a stopwatch. Times required to collect a mud pellet, carry it to the nest and pack it into the nest were also measured.

The equation of Lasiewski & Dawson (1967) was used to predict standard metabolic rate (SMR) of the South African cliff swallow and the cost of flight was estimated from aerodynamic theory of flapping flight as given by Pennycuick (1969) and Tucker (1973) (see Appendix).

The South African cliff swallow spent most of the 24-h day in the nest (Table 1). This included about 9 h spent sleeping in the nest at night. Nest building was a minor component of total activity during the incubation and nestling periods, while most time was spent foraging during the nestling period (Table 1).

Flight velocity was determined to be 9,2 m s^{-1} (range 8,3–11,6) (33,1 km h^{-1}). At this velocity the metabolic cost of flight for a 21,7-g bird is predicted to be 2,59 W (or 6,8 SMR) (Tucker 1973). Measurement of flight velocity was made on a calm day so that there was no need for correction because of ambient wind velocity. Existence metabolism in the nest was taken to be 1,5 SMR (0,57 W) and metabolic cost of nest

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building (i.e. packing mud and collecting mud) was assumed to be 2 SMR (0,76 W). These SMR figures were similar to those used for the American cliff swallow *Hirundo pyrrhonota* by Withers (1977), who also pointed out that an error as much as 50% in these two assumptions would only result in a 7% error in the daily energy expenditure because of the large contribution of flight relative to non-flight activities.

The highest daily energy expenditure was during the feeding of nestlings when 0,062 W g^{-1} was expended, in comparison to nest construction and during incubation when 0,059 and 0,053 W g^{-1} was expended respectively. The highest food harvest rates (24-h day/time spent foraging) were obtained during incubation when only 7 h per day was spent foraging (Table 1). The harvest rates given in Table 1 are probably an underestimation as some time on the wing is probably spent in social activities and not foraging but no estimation of the time spent in social activities was made.

To calculate the cost of building a nest the time spent on the three actions which constitute a nest-building trip was measured for a number of individual birds and the mean times spent on the mud-gathering site, on the nest site and travelling between the nest and mud source were used to calculate energy expenditure while building a nest. A single mud pellet was assumed to have a mass of 0,54 g [mean nest mass was 804 g, mean number of pellets was 1550 per nest (Earlé 1985)]. By carrying this mud pellet about 1% is added (Withers 1977) to the metabolic cost of flying which was considered a small enough extra cost to be ignored in further calculations. The number of trips required to build a nest was about 1550 if it is assumed that each pellet in the nest required a trip.

During each 60-s period of nest building 11,4 s was spent on the mud-gathering site, 28,6 s was spent on the nest site packing mud and 20 s flying between the two sites (Earlé 1985). The metabolic rate during such a 60-s cycle was found to be 3,6 SMR

$$\left[= \left(\frac{11,5}{60} \times 2\right) + \left(\frac{28,6}{60} \times 2\right) + \left(\frac{20}{60} \times 6,8\right)\right]$$

and the total cost of nest construction was thus:

Mean cost of whole cycle (× SMR)	×	SMR (W)	×	number of trips	×	length of whole cycle	=	kJ (Withers 1977)
3,6	×	0,38	×	1550	×	60	=	127 kJ

As the nest of the cliff swallow is usable for a number of years and up to four broods can be raised in a single nest per year (Earlé 1986), the amount of energy spent in building a nest, namely 127 kJ, is very small. The remarkably similar energy output for nestbuilding in the American cliff swallow (122 kJ) (Withers 1977) indicates a very similar strategy in breeding and probably colonialism. The daily energy expenditure in raising nestlings of 3,54 SMR is higher than that of both the American cliff swallow (Withers 1977) and the purple martin *Progne subis* (Utter & LeFebvre 1973) where the costs are 3,05 and 3,02 SMR respectively. This higher cost to South African cliff swallows in raising chicks is probably related to food availability especially as observations were made in exceptionally dry years which resulted in a relatively low biomass of food being available (Earlé, unpubl. data). Although time-budget estimates of daily energy expenditure in birds can be in error by 20–40% (Weathers, Buttemer, Hayworth & Nagy 1984), the methods used were the same as those used by Withers (1977) for the American cliff swallow and are thus directly comparable with that study.

Table 1 Daily time and energy budgets of *Hirundo spilodera* during nest construction, incubation and nestling periods

	Nest construction		Incubation		Nestlings	
	Hours	kJ	Hours	kJ	Hours	kJ
Foraging	8,21	76,5	7,00	65,2	9,22	85,9
Nest building	3,69	10,1	0,11	0,3	0,03	0,1
In nest	12,10	24,8	16,89	34,6	14,75	30,3
Total[a]	24,00	111,4	24,00	100,1	24,00	116,3
Harvest rate (Total[a]/h foraging; W)	3,77		3,97		3,51	
Daily energy expenditure W g^{-1}	0,059		0,053		0,062	
× SMR	3,37		3,03		3,54	

[a] Conversion of time to energy assumes flight cost (foraging) = 2,59 W, cost of nest construction = 0,76 W, and existence metabolism = 0,57 W.

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Appendix

(i) Measurements and formulae used in calculating time and energy used by the South African cliff swallow during the breeding season

Measurements of *Hirundo spilodera* for energy estimates:
Body weight 21,7 ± 1,4 g (n = 36)

Mean flight velocity 9,2 m s^{-1} (n = 30) (range 8,3–11,6 m s^{-1}).

All units are S.I. and the conversion factors are 1 watt (W) = 0,86 kcal h^{-1} and 1 kilojoule (kJ) = 0,239 kcal.
Weight (W) is measured in newtons and mass (m) in kilograms. $W = mg$ where g = 9,81 m s^{-2}.

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Formulae used for:

Standard metabolic rate (SMR)
$P_{ib} = 6{,}15 m^{0{,}724}$ (Lasiewski & Dawson 1967) where
P = power
i = input
b = basal
m = mass (kg)

Metabolic cost of flight
$P_i/(WV) = 0{,}896 W^{-0{,}227}$ (Tucker 1973) where
W = weight (N)
V = flight velocity

Estimating daily energy expenditure (DEE)
Total kJ (converted to watt) ÷ 24 (h) ÷ weight of bird (g) = $W\,g^{-1}$
Estimating food harvest rate
Total kJ (converted to watt) ÷ total hours foraging = W

(ii) Ambient temperatures during observations

(a) Nest building 12 October 1983 max. 27,9°C; min. 13,9°C; mean 19,9°C.

(b) Incubation 29 November 1983 max. 23,2°C; min. 14,6°C; mean 18,9°C.

(c) Nestling 16 October 1984 max. 23,8°C; min. 7,5°C; mean 15,9°C.

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