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# The growth of Kestrel nestlings in southern Finland

Seppo Kuusela & Tapio Solonen

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The growth of Kestrel nestlings was analyzed and modelled on the basis of observations of feeding frequency and measurements of weight and wing length at four nests in southern Finland. An energy budget was then constructed. For this a camera method to observe feeding was tested and found useful.

The growth rate of the weight fitted to a logistic curve is higher in Finland than in Central Europe. The weight gain culminated on the eighth day from the hatching of the nestlings. The growth of the wing length fitted to a linear regression. The wing length is about 67 % of its maximum at the time of fledging. Feeding frequency and daily growth rate of the nestlings correlated negatively with the daily rainfall.

Relations between nest spacing and feeding of the Kestrel are discussed. It is suggested that the optimal foraging of the Finnish Kestrels is negatively affected by its dependence on the old nests of the Hooded Crow in the agricultural land.

*Seppo Kuusela & Tapio Solonen, Department of Zoology, University of Helsinki, P. Rautatiekatu 13, SF-00100 Helsinki 10, Finland.*

## 1. Introduction

The growth patterns of birds are well-known (see e.g. Ricklefs 1968, 1974). In raptors, as in other altricial land birds the growth curve is sigmoidal in form and the growth rate is inversely correlated with body size. The nestling period of different raptor species varies from 26 to 200 days (e.g. Newton 1979). However, the interpretation of the field data on nestling growth seems to be "at the state of art", because the data is not published (cf. O'Connor 1980).

The growth of Kestrel, *Falco tinnunculus*, nestlings has been studied previously both in Central Europe (Cavé 1968, Piechocki 1970) and in western Finland (Korpimäki et al. 1979). In this paper we examine the growth in weight and in wing length, feeding frequency and energy requirements of Kestrel nestlings in southern Finland. The growth pattern is then commented on in relation to the published data (see above) and a countrywide survey of Finnish Kestrels 1974-77 (Kuusela 1983).

## 2. Material and methods

The field material was collected from four nests in southern Finland: A) Sipoo, Hertsby, hatching date 17.6.1974, 5 nestlings (weight and wing length of each chick were measured 8 times); B) Porvoo mlk., Norrveckoski, 7.7.1974, 2 (3); C) Helsinki, Malminkartano, 9.6.1975, 4 (7); D) Pornainen, Laha, 22.6.1976, 4 (7). Nest B was situated in an old nest of the Magpie, *Pica pica*, and the others were in nests of the Hooded Crow, *Corvus corone cornix*. The small nestlings were weighed with a 100 g Pesola spring balance (accuracy 0.1 g), large nestlings with 300 g balance. Nests A, C and D were visited at 1-4 days' intervals, and nest B every second week. The wing length was measured with a ruler to the nearest millimetre according to the maximum method (Svensson 1970).

The behaviour of the parents and the chicks at nest D was observed with binoculars (10 × 50) at a distance of 500 m (in total 20.5 hours) and with a camera (Braun Nizo, S-80). The super-8 cinema camera taking a picture every minute was 1.5 m above the interior of the nest. The camera was in use for 18 days between June 25 and July 18. The film made it possible to count the feeding frequency and the length of each feeding visit and, also, to identify some of the prey items.

From the field material we estimated the parameters of models for nonlinear growth by Marquart's iterative algorithm (Conway et al. 1970), which makes use of the least square technique. Ricklef's (1967) graphical method was used in the comparisons of our field data with the results of Cavé (1968), Korpimäki et al. (1979) and

Piechocki (1970). In these studies only the mean values of the growth of the weight have been published. An energy budget for the nestlings was constructed on the basis of the weight data and the equations given by Cain (1976) and Kendeigh et al. (1977).

## 3. Results

The weight of a one day old chick varied from 16 to 21.9 g, at the age of ten days from 136 to 164 g (Fig. 1). At the end of the nestling period, the weight of the chicks decreases somewhat. The logistic model for the weight increase was

$y(t) = 224.4\,[1 + \exp(2.67 - 0.331t)]$

($F = 153.15$, $df_1 = 1$, $df_2 = 118$, $P < 0.01$, Fig. 1). Using Ricklefs' graphical method the time interval for the growth from 10 to 90 % of the asymptote was 13.2 days (Table 1).

The linear regression model

$y(t) = 0.46 + 6.49t$

($r = 0.99$, $df = 118$, $P < 0.01$)

fits the data, but also the power function describes the field material well ($F = 146.0$, $df_1 = 1$, $df_2 = 118$, $P < 0.001$. Thus, the model $y(t) = 5.74t^{1.044}$ does not differ significantly from the linear regression (Fig. 1). The wing length of a one day old chick was 17.6 mm on average (Fig. 1). The wing length reached 100 mm at the age of 7–9 days. Wing growth continues after fledging as it is about 67 % of the adult wing length (see Piechocki 1970 for adult) on the 25th day from hatching. It stops, however, and is asymptotic to time. The nonlinear model would seem a more realistic description of the wing growth pattern, although our material covers only the nestling period.

At the nest, as followed by the two independent methods, feeding frequency varied from 2 to 11 times per day (on average 6.8). The two methods gave consistent results. Feeding sessions lasted from less than 2 min. to more than 16 min. being longest at the beginning of the nestling period.

Among the prey items in 85 feedings filmed, 10 Skylarks *Alauda arvensis* and 4 *Microtus* voles were identified. Most of the prey items were not possible to identify. Feeding frequency and the daily weight gain of the nestlings correlated negatively although not significantly with the daily rainfall.

Assuming that the energy content of growing tissue is 7.8 kJ/g fresh weight (after Ricklefs 1974) and the energetic efficiency of

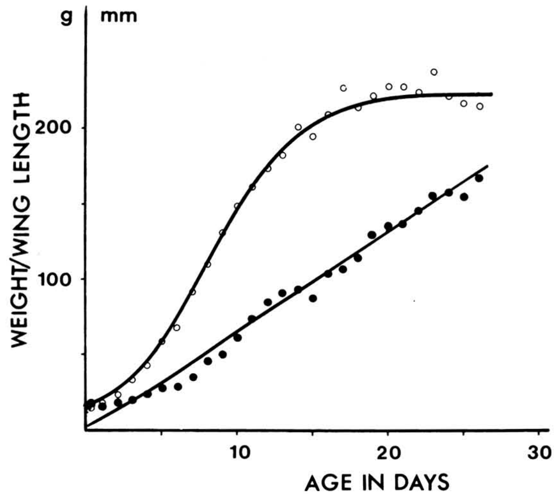


Fig. 1. The increase in weight (upper curve) and wing length (lower curve) of Kestrel nestlings in southern Finland. The mean values of the measurements are given together with the fitted logistic and power functions. The number of measurements per age class ranged from 2 to 7 averaging 4.3.

the growth is 75 % (after Ricklefs 1974, see also Sylvén 1982), the energy requirement of the weight gain (of 224 g) can be estimated as about 2180 kJ/bird. The weight gain culminated in the eighth day from hatching. The daily energy budget (DEB) calculated from the weight data ranged from 54 kJ/bird/day on the first day of nestling life to 464 kJ/bird/day from the 24th day onwards. The DEB was estimated to be about 80 % of the gross energy intake (GEI; cf. Cain 1976).

## 4. Discussion

Food competition between siblings in the nest may be dominated by the female chicks of the Kestrel (Cavé 1968). In the present study, the nestlings were not sexed because it was not possible to ensure the identifications. The weight variation of one-day old chicks was relatively great. In this respect, significant differences between localities do not seem to exist. Neither is the weight of nestlings at fledging time different in open (tree) and hole-nests. However, the nestling period seems to be relatively long and the growth rate low in nests situated in high buildings (Table 1). Moreover, the wing growth may be a stepwise

Table 1. The growth parameters of Kestrel nestlings accoring to four different data sets: Cavé 1968 (Holland), Piechocki 1970 (GDR), Korpimäki et al. 1979 (western Finland), and this study (southern Finland). The inflection point is the age at which the absolute maximum growth rate is attained, K is constant proportional to the overall growth rate, $t_{10-90}$ is time interval for growth from 10 to 90% of the asymptote. For comparison, all the parameters were estimated with Ricklefs graphical method for the logistic model. In Cavé's data the mean weight of sexes was used.

| | Asymptote (g) | Inflection point (days) | Growth rate | ($t_{10-90}$) | N |
|---|---|---|---|---|---|
| Holland | 265 | 8.7 | 0.296 | 14.8 | ca. 510 |
| GDR | 225 | 13.1 | 0.236 | 18.6 | 44 |
| Finland | | | | | |
| western | 220 | 7.1 | 0.320 | 13.7 | 243 |
| southern | 224 | 7.8 | 0.332 | 13.2 | 120 |

process due to body moults of nestlings. However, these statements can not be proved rigorously from the published data on the Kestrel. A difficulty also arises in the interpretation of feeding frequencies. For instance, the availability of prey items as well as the hunger of nestlings may be greater after rainy days (cf. Cavé 1968:380). Interspecific comparisons have been more fruitful (e.g. Newton 1979).

It was estimated that of the total energy of prey killed 75 % is consumed, on average. Thus, using the data on gross energy intake, the amount of prey (= 17 800 kJ) needed to feed a Kestrel nestling from hatching to the age of 30 days corresponds to 138 Field Voles, *Microtus agrestis* (mean weight 21 g, about 129 kJ; Hansson & Grodźinski 1970). In our study nest, daily requirements per chick increased from about one to six voles during the first three weeks. Because energy limitation of growth rates has not been rejected as an explanation of observed growth patterns, it may be important to study the energetics of the nestling growth in connection with optimal foraging models. The nests of Finnish Kestrels are usually situated at forest edges close to a good hunting habitat but probably not centrally in the hunting area. Preferred hunting areas are fields, pastures, ditches, grass marshes, etc. As far we know, no observations of the Kestrel hunting in the forest have been published. We suggest that optimal foraging (cf. Andersson 1981, Rudolf 1982) of Finnish Kestrels is interfered with significantly by its dependence on the old nests of the Hooded Crow in the agricultural land. Direct interactions between these two species are often observed. The indirect link suggested should be tested on the basis of the assumption that changes in habitat heterogeneity of agricultural land are the main factor affecting the breeding densities of Kestrels (e.g. Kuusela 1983).

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