

- Africa. Trustees of the John Voelcker Bird Book Fund, Cape Town.
- MARCHANT, S., AND P. J. HIGGINS. 1990. Handbook of Australian, New Zealand and Antarctic Birds. Vol. 1., Part B. Oxford Univ. Press, Melbourne.
- MARION, W. R. 1977. Growth and development of the Plain Chachalaca in south Texas. *Wilson Bull.* 89:47-56.
- MOSS, R., AND I. LOCKIE. 1979. Infrasonic components in the song of the Capercaillie *Tetrao urogallus*. *Ibis* 121:95-97.
- NEWTON, A. 1899. A dictionary of birds. Adam and Charles Black, London.
- NIETHAMMER, G. 1966. Sexualdimorphism am Osophagus von *Rostratula*. *J. fur Ornithol.* 107: 201-204.
- PAVESI, P. 1874. Intorno ad una nuova forma di trachea di *Manucodia*. *Ann. Mus. Civ. Stor. nat. Genova* 6:315-324.
- RAND, A. L. 1938. Results of the Archbold Expeditions. No. 22. On the breeding habits of some birds of paradise in the wild. *Amer. Mus. Novitates* 993: 1-8.
- RAND, A. L., AND E. T. GILLIARD. 1967. Handbook of New Guinea birds. WEIDENFELD & NICOLSON, London.
- SCHODDE, R., AND S. C. TIDEMANN. [EDS.]. 1988. Reader's Digest complete book of Australian birds. Reader's Digest, Sydney.
- SCOTT, P. 1972. The swans. Michael Joseph, London.
- SETH-SMITH, D. 1923. The birds of paradise and bower birds. *Avicult. Mag. Ser. 4*, 1:41-60.
- SNOW, D. 1982. The Cotingas. *Br. Mus. (Nat. Hist.)*, London.
- TOPSELL, E. 1972. The fowles of heaven, or history of birds. T. P. Harrison, and F. D. Hoenhiger [eds.]. Univ. of Texas Press, Austin.
- URBAN, E. K., C. H. FRY, AND S. KEITH. [EDS.] 1986. The birds of Africa. Vol. 2. Academic Press, London.
- ZAHAVI, A. 1975. Mate selection—a selection for a handicap. *J. Theor. Biol.* 53:205-214.

*The Condor* 96:555-559

© The Cooper Ornithological Society 1994

## DETERMINATION OF NESTLING AGE AND LAYING DATE IN TENGMALM'S OWL: USE OF WING LENGTH AND BODY MASS<sup>1</sup>

B.-G. CARLSSON AND B. HÖRNFELDT

*Department of Animal Ecology, University of Umeå, S-901 87 Umeå, Sweden*

*Key words:* Tengmalm's Owl; nestlings; aging; laying date; wing length; mass; food supply.

Laying date is a central parameter in many ecological studies on birds. The date of the first egg is commonly estimated by backdating during laying from number of eggs and laying interval. Alternatively, laying dates of first egg can be calculated by backdating from age of oldest nestlings and length of the incubation period. The latter method may be advantageous, for example, in birds which are sensitive to disturbances during the early phase of breeding. Wing length is a good indicator of age in nestlings of, for example, Willow Grouse (*Lagopus lagopus*) (Myrberget 1975), House Martin (*Delichon urbica*) (Bryant 1975), Ural Owl (*Strix uralensis*) (Eriksson et al. 1984), Red-tailed Hawk (*Buteo jamaicensis*) (Bechard et al. 1985), and Northern Harrier (*Circus cyaneus*) (Saunders and Hansen 1989). For

Tengmalm's Owl (*Aegolius funereus*) nestlings, Korpimäki (1981) presented data on wing length and mass for a few nestlings, suggesting that wing length is a good estimator of age in this species.

Tengmalm's Owl is a cavity breeder readily accepting nest boxes. In northern Sweden, voles are the most important prey, and the breeding success of the owls reflects vole abundance (Löfgren et al. 1986, Hörnfeldt et al. 1990). Voles fluctuate in a three- or four-year cycle (e.g., Hörnfeldt 1978, 1994; Hörnfeldt et al. 1986).

Here, we present age-wing length and age-mass curves for wild Tengmalm's Owl nestlings in northern Sweden. The results were obtained by measuring nestlings during two years, characterized by different food (vole) supply. We explore the consistency of these parameters in different years and thus the usefulness of wing length and mass for aging nestlings and determining laying dates.

### MATERIALS AND METHODS

The study was carried out in the county of Västerbotten, northern Sweden (approximately 64°N, 20°E), as

<sup>1</sup> Received 29 December 1993. Accepted 10 January 1994.

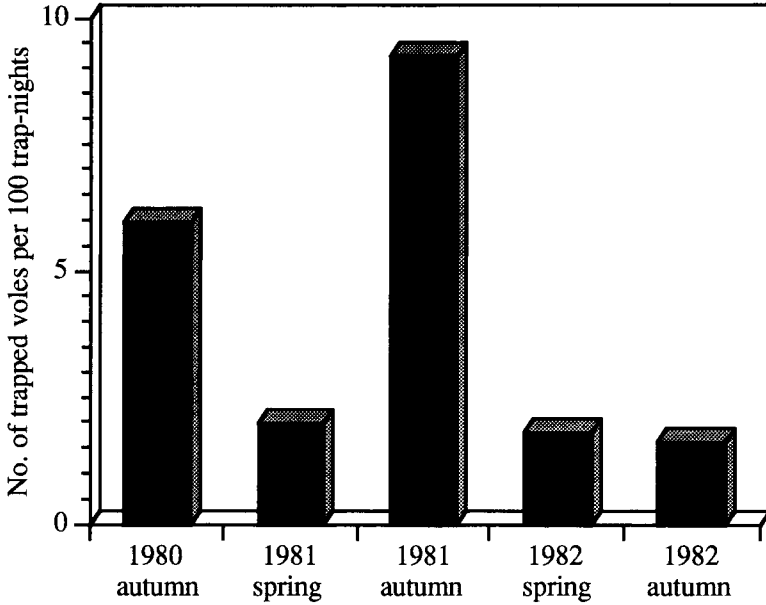


FIGURE 1. Trapping indices for voles during the nestling size study period in 1981–1982.

part of a long-term study on the ecology of Tengmalm’s Owl (e.g. Löfgren et al. 1986, Carlsson et al. 1987, Hörnfeldt et al. 1990). The owls bred in nest boxes of standardized size (20 × 20 cm bottom area). Within the long-term study area boxes were usually inspected at intervals of three to four weeks during March to June.

In two seasons, 1981 and 1982, we used nestlings within an intense-study area about 1,300 km<sup>2</sup> to construct age-wing length and age-mass curves. Wing length (mm) of nestlings was measured with a ruler according to the maximum length method (Svensson 1975). Mass

(g) was measured with a Pesola spring balance (100 g or 300 g). Nests in the intense study area were visited most frequently around hatching and about 10 days onwards, every third or fourth day in 1981 and at daily intervals in 1982. In 1981, 104 nestlings (from 22 nests) and in 1982, 82 nestlings (from 20 nests) were studied from 16 April to 10 June and 27 April to 17 June, respectively.

In the long-term study area, vole abundance was monitored by snap trapping twice a year, in late May and in late September. Trappings were made in 58 regularly distributed 1-ha-plots. The trapping effort was

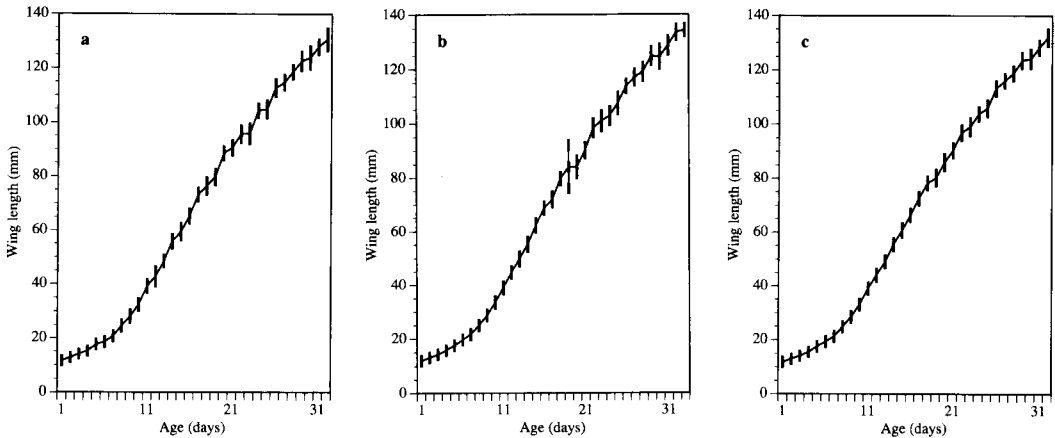


FIGURE 2. Wing length in relation to age of wild Tengmalm’s Owl nestlings in 1981 ( $n = 104$ ) (a), 1982 ( $n = 82$ ) (b), and 1981–1982 (pooled data) ( $n = 186$ ) (c). Mean  $\pm$  SE is given for each day of age. Total number of measurements was 622, 828 and 1450, respectively.

normally 150 trap nights per 1-ha-plot and the average total trapping effort per period was about 8,470 trap nights (range: 8,340–8,505) in 1980–1982. As an index of vole density, number of voles trapped per 100 trap nights was calculated. We used the pooled number of *Clethrionomys glareolus*, *C. rufocanus*, and *Microtus agrestis*, which together made up >90% in the trappings and in the owl's breeding time diet (Hörnfeldt et al. 1990). Vole indices were similar in spring in 1981 and 1982 (Fig. 1). Still, 1981 can be characterized as a peak and 1982 as a decline year. This is because indices suggested a steeper decline in density in the winter of 1981/1982 than in 1980/1981, and densities increased in summer 1981, while they stayed low in summer 1982 (Fig. 1; see also Hörnfeldt et al. 1990; Hörnfeldt 1994).

We compared laying dates for clutches backdated from both the 'laying method' and 'wing-length method', using the available nestling data from the long-term study area in 1981–1982 and 1984–1985. The laying method was used as a reference because it is likely to contain less errors of estimation. A prerequisite for these comparisons was that we knew the wing length of the oldest nestling. Thus, we only used nests where no nestling mortality had occurred at time of visits. The 'laying method' required that nests were visited before laying ended. Then laying date was backdated by using a laying interval of two days (Korpimäki 1981) and by assuming that the last egg was laid on the day it was found. Thus, this method has an inherent error of at most two days in estimating laying date. The 'wing-length method' required that nests were visited during brood rearing before fledging. Then laying date was backdated after aging the oldest nestling by its wing length (see below) and adding the length of the average incubation period (29 days; Korpimäki 1981). Thus, this method has two inherent errors in estimating laying date, i.e. relating to estimates of length of incubating period and of age of the oldest nestling.

## RESULTS

Wing lengths (mean  $\pm$  SE) of birds of known age during day one to day eight in 1982 were: 12.1  $\pm$  0.1 mm ( $n = 49$ ), 13.2  $\pm$  0.2 mm ( $n = 39$ ), 14.0  $\pm$  0.2 mm ( $n = 34$ ), 15.7  $\pm$  0.2 mm ( $n = 45$ ), 17.6  $\pm$  0.2 mm ( $n = 42$ ), 19.3  $\pm$  0.3 mm ( $n = 43$ ), 21.4  $\pm$  0.4 mm ( $n = 38$ ), and 24.9  $\pm$  0.4 mm ( $n = 37$ ), respectively. From these values we interpolated the age of all young nestlings in 1981, that were first measured at an age of  $\leq 4$  days, and for about 28% of the nestlings in 1982. Nestlings in 1981 and 1982 showed similar wing growth rates throughout the nestling period (compare Figs. 2a and 2b). The differences between mean wing lengths at each day throughout the nestling period were small between years, and they were only significantly different at four out of 32 days (Fig. 3a). These overall large similarities between years justified combining age-wing length curves for the two years as a basis of practical reference (Fig. 2c). The relationship between age and wing length was best described by two separate equations for wing lengths (WL) < 27 mm (1) and for wing lengths  $\geq 27$  mm (2), respectively:

$$\text{Age (days)} = (-1.023 + \log(\text{WL}))/0.044 \quad (1)$$

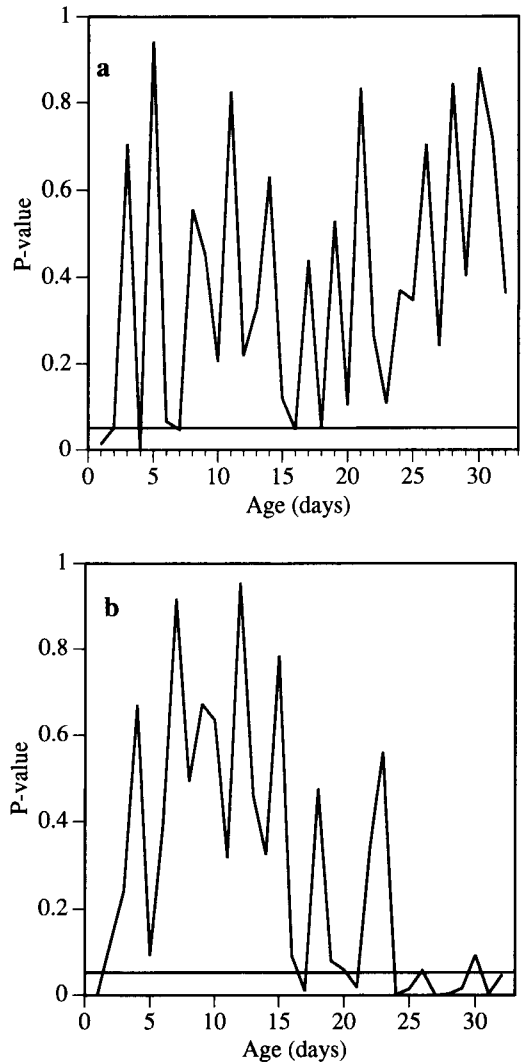


FIGURE 3.  $P$  values for two-sample  $t$ -tests of mean nestling (a) wing lengths and (b) masses in 1981 and 1982.  $P = 0.05$  is indicated. Due to low sample sizes, Mann-Whitney  $U$ -tests were used for days 19 and 32.

$$\text{Age (days)} = 53.73$$

$$- \sqrt{(2887 - (33.70 + \text{WL})/0.06855)} \quad (2)$$

Laying dates backdated by the wing length and laying methods (see MATERIALS AND METHODS) showed small differences both among years, characterized by different food situations (Fig. 1; Hörnfeldt et al. 1990), length curves, mass curves leveled out before fledging. In addition, the mass curve leveled out at a lower mass in 1982 than in 1981 (Fig. 4a, b). Mass was significantly or marginally significantly different at nestling ages 24–

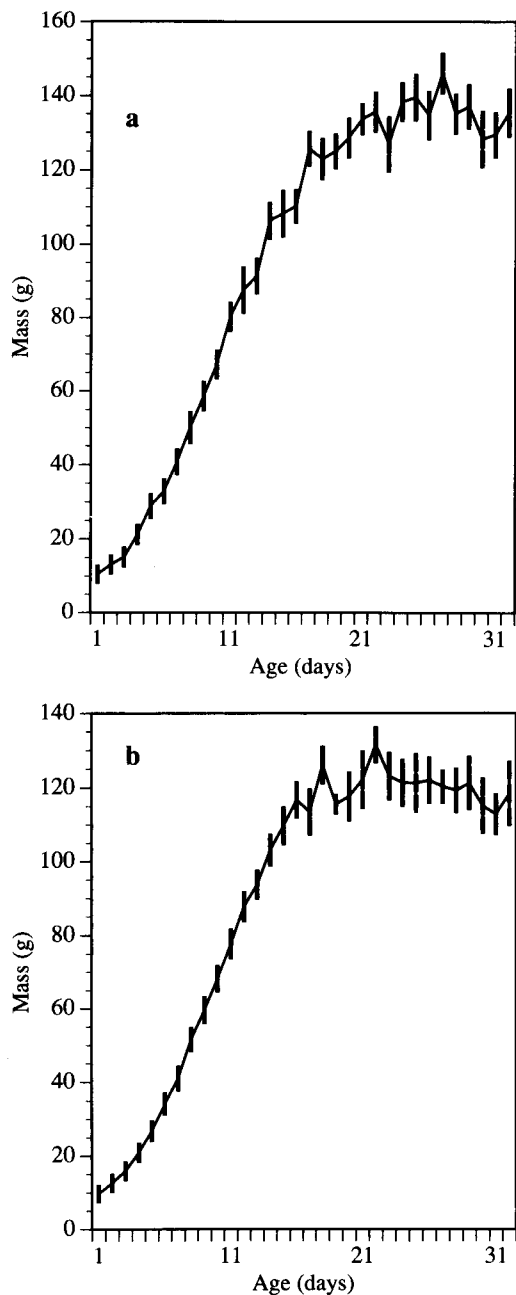


FIGURE 4. Body mass in relation to age of wild Tengmalm's Owl nestlings in (a) 1981 ( $n = 104$ ) and in (b) 1982 ( $n = 82$ ). Mean  $\pm$  SE is given for each day of age. Total number of measurements was 618 and 827, respectively. Food supply (voles) was at a peak in 1981 and declined in 1982.

TABLE 1. Comparison of laying dates for clutches determined by both the laying and wing length method, in relation to year and time of season (years combined). Number of clutches in parentheses. Level of significance ( $P$ ) according to Wilcoxon matched-pairs signed-ranks test.

	Mean $\pm$ SE		$P$
1981	$-0.1 \pm 0.4$	(27)	0.75
1982	$1.1 \pm 0.3$	(36)	<0.001
1984	$1.3 \pm 0.4$	(12)	<0.05
1985	$1.1 \pm 0.6$	(9)	0.18
Before 20 April	$0.2 \pm 0.3$	(56)	0.33
After 20 April	$1.8 \pm 0.2$	(28)	<0.001

32 days (Fig. 3b). In addition to marked annual differences and a shorter growth period, mass also showed larger overlap among ages than did wing length.

#### DISCUSSION

It was more reliable to age Tengmalm's Owl nestlings by wing length than by mass, presumably because mass gain was more sensitive to annual variation in food supply than was growth of wing length. When vole numbers were declining in 1982, nestling mass leveled out at a lower value than when food was more abundant in 1981 (Fig. 3b, 4; compare Fig. 1). Comparisons of laying dates determined by the wing length and laying methods gave similar results. The small differences were subtle and they were partly explained by our conservative assumption that laying females had laid the most recent egg on the day it was found. For the laying method, this underestimated laying date by about one day, compared with the more realistic assumption that this egg was laid one day earlier (the laying interval is two days; Korpimäki 1981). Also, differences were influenced by other assumptions for backdating. The length of the incubation period, for example, is likely to decrease somewhat with increasing ambient temperature (cf. König 1969). This is likely to yield somewhat too early laying dates for the wing length than for the laying method late in the season (Table 1). In conclusion, the wing length method is appropriate for determining laying dates and clearly is a suitable alternative to using laying data. In our ecological studies of Tengmalm's Owl, we have used both of these methods for determining laying dates (e.g., Carlsson et al. 1987, Hörnfeldt et al. 1990). However, the wing length method may be preferable since it is likely to cause less disturbance by reducing the necessity of inspections in the more sensitive laying phase. In principle it seems likely that this method can also be applied for other *A. funereus* populations. However, we recommend researchers in other areas to check, with a sample of known-age nestlings' wing length, whether they must modify the method.

We are greatly indebted to T. Holmberg who inspired us to make this study, and to all who assisted in the field work, especially to Åke Nordström and Anders Bergman. We are also grateful to O. Löfgren for stimulating discussions, and to E. Korpimäki, J. Marks, Å.

Norberg, C. Otto, and an anonymous reviewer for comments on the manuscript. G. Marklund assisted in figure drawings. The study was financially supported by grants to B. Hörnfeldt from the National Swedish Environment Protection Board and from Stiftelsen Olle Engkvist, Byggmästare, and to B.-G. Carlsson from Helge Ax:son Johnsons Stiftelse.

#### LITERATURE CITED

- BECHARD, M. J., B. W. ZOELICK, AND M. NICKERSON. 1985. Accuracy in determining the age of nestling Red-tailed hawks. *J. Wildl. Manage.* 49:226–228.
- BRYANT, D. M. 1975. Breeding biology of House Martins *Delichon urbica* in relation to aerial insect abundance. *Ibis* 117:180–216.
- CARLSSON, B.-G., B. HÖRNFELDT, AND O. LÖFGREN. 1987. Bigyny in Tengmalm's Owl *Aegolius funereus*: effect of mating strategy on breeding success. *Ornis Scand.* 18:237–243.
- ERIKSSON, D., A. LUNDBERG, AND B. WESTMAN. 1984. Estimating age of Ural Owl nestlings from body part measurements. *Ann. Zool. Fennici* 21:313–316.
- HÖRNFELDT, B. 1978. Synchronous population fluctuations in voles, small game, owls, and tularemia in northern Sweden. *Oecologia* 32:141–152.
- HÖRNFELDT, B. 1994. Delayed density dependence as a determinant of vole cycles. *Ecology* 75:791–806.
- HÖRNFELDT, B., B.-G. CARLSSON, O. LÖFGREN, AND U. EKLUND. 1990. Effects of cyclic food supply on breeding performance in Tengmalm's Owl (*Aegolius funereus*). *Can. J. Zool.* 68:522–530.
- HÖRNFELDT, B., O. LÖFGREN, AND B.-G. CARLSSON. 1986. Cycles in voles and small game in relation to variations in plant production indices in northern Sweden. *Oecologia* 68:496–502.
- KORPIMÄKI, E. 1981. On the ecology and biology of Tengmalm's Owl (*Aegolius funereus*). *Acta Univ. Ouluensis A* 118. *Biol.* 13:1–84.
- KÖNIG, C. 1969. Sechsjährige Untersuchungen an einer Population des Rauhfußkauzes, *Aegolius funereus* (L.). *J. Ornithol.* 110:133–147.
- LÖFGREN, O., B. HÖRNFELDT, AND B.-G. CARLSSON. 1986. Site tenacity and nomadism in Tengmalm's Owl (*Aegolius funereus* (L.)) in relation to cyclic food production. *Oecologia* 69:321–326.
- MYRBERGET, S. 1975. Age determination of Willow Grouse chicks. *Norw. J. Zool.* 23:165–171.
- SAUNDERS, M. B., AND G. L. HANSEN. 1989. A method for estimating the ages of nestling Northern Harriers (*Circus cyaneus*). *Can. J. Zool.* 67:1824–1827.
- SVENSSON, L. 1975. Identification guide to European passerines. Naturhistoriska riksmuseet, Stockholm.

*The Condor* 96:559–565  
© The Cooper Ornithological Society 1994

### BEHAVIOR AND VOCALIZATIONS OF *GYALOPHYLAX* AND *MEGAXENOPS* (FURNARIIDAE), TWO LITTLE-KNOWN GENERA ENDEMIC TO NORTHEASTERN BRAZIL<sup>1</sup>

BRET M. WHITNEY

*Field Guides Incorporated, P.O. Box 160723, Austin, TX 78716-0723*

JOSÉ FERNANDO PACHECO

*Instituto de Biologia, Depto. de Zoologia, Cidade Universitária, Universidade Federal do Rio de Janeiro 21941-000, Rio de Janeiro, RJ, Brasil*

**Key words:** *Gyalophylax*, *Megaxenops*, *Furnariidae*; behavior; vocalizations; relationships; caatinga; Brazil.

Among the least-known members of the large and diverse family Furnariidae are two locally distributed, monotypic genera endemic to northeastern Brazil: *Gyalophylax* Peters (1950) and *Megaxenops* Reiser (1905). In September 1991 and November 1993, as part of an avifaunal survey of Ceará, western Pernambuco, and

northern Bahia, we observed the habitat, behavior, and vocalizations of the Red-shouldered Spinetail (*Gyalophylax hellmayri*) and the Great Xenops (*Megaxenops parnaguae*). Our observations are the most detailed to date on these birds, and allow a more informed elucidation of intra-familial relationships than has been possible in the past.

Terminology for foraging behavior follows Remsen and Robinson (1990). Tape recordings were made with Nagra 4.2 and Sony TCM-5000 tape recorders, and Sennheiser ME-80 shotgun microphones. All tape recordings have been, or will be, archived at the Library of Natural Sounds (LNS), Cornell Laboratory of Ornithology, Ithaca, New York, and the Arquivo Sonoro

<sup>1</sup> Received 7 January 1994. Accepted 18 January 1994.