Table 1. Egg dimensions of 24 clutches of Golden Plover *Pluvialis apricaria*: Length (L), Breadth (B) and Volume Index (VI), and calculated initial density, initial weight and weight loss from the regression (y = 389x + 168). Note that the Volume Index of 64.78, calculated from the mean Length and mean Breadth is slightly lower than the value given here, which is the mean value for the Volume Index of each clutch.

Mean (S.D.)			Calculated		
L (mm)	B (mm)	VI	Initial density	Initial weight (g)	Weight loss (g/day)
50.43 (1.56)	35.84 (1.02)	64.95 (4.73)	0.509	33.06 (2.41)	0.17

where three of four eggs were later found to be dead, the three dead eggs lost weight at the same rate as the live egg. This suggests that water loss is a passive progress, dependent on average temperature and relative humidity but not affected by the metabolism of the developing embryo. If this reasoning is correct, it suggests that the low rate of water loss of our Golden Plover eggs might be related to the relatively humid nesting habitat: all these nests were in blanket bog vegetation over deep peat. It is further possible that the considerable variation between clutches might be related to difference humidity around each nest.

To return to the main point of this note, it is certainly possible to estimate, from relative egg density, whether the clutch is in its first, second or third 10-day period of incubation. However, the method is not sufficiently accurate to allow the exact date or hatching to be predicted, and visits every two to three days would still be necessary once the relative density falls below 0.45. Reweighing the eggs at least once during incubation, to get an estimate of the rate of weight loss for that particular clutch, does allow more precision.

Lastly, of course, the fresh egg weight can be calculated from the relationship: Volume Index × 0.509. The mean volume index of 24 clutches was 64.95 (S.D. 4.73), and the mean weight of a newly laid egg is therefore estimated to be 33.06 g (S.D. 2.41 g).

Acknowledgement

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Growth of Common Sandpiper chicks

P.K. HOLLAND[1] & D.W. YALDEN[2]

[1]*2 Rennie Court, Brettargh Drive, Lancaster LA1 5BN, UK*
[2]*Department of Environmental Biology, University of Manchester, Manchester M13 9PL, UK*

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Common Sandpipers grow from 8.70 g at hatching to 40.11 g at fledging, at a rate of 1.65 g day^{-1}, and their bills lengthen from 9.20 mm to 20.83 mm over the same period, a rate of 0.61 mm day^{-1}. Growth in mass in probably sigmoidal, and bill length is a better criterion for ageing very young and nearly fledged chicks. In the middle range, bill lengths and mass are closely correlated, so allowing the use of relative mass to judge a chick's condition.

Introduction

In a previous paper (Holland *et al.* 1982), we suggested that chicks of Common Sandpiper *Actitis hypoleucos* grow from 8 g at hatching to about 40 g at fledging, 19 days later. We have not, however, published any details of growth rates, and are not aware of any other such publications on Common Sandpipers. This paper summarises the information available to use after 12 seasons of fieldwork.

Material and method

Common Sandpiper chicks are difficult to find except as newly hatched young in or near the nest. Once fully mobile they are adept at hiding in such places as burrows and under boulders. When first fledged, however, they are vulnerable to capture in mist nets set across the breeding streams. Thus we have most information for very young and just-fledged chicks. Chicks were weighed (to the nearest 0.1 g when very young, otherwise to 0.5 g) when handled for ringing. Bill-lengths (to the nearest 0.5 mm) also have been measured, with a ruler, in response to the appeal for more information by Rhys Green (1984). Chicks were not weighed if it was wet or windy, nor if it was likely to attract further attention to the nest site.

We have collected information on the following categories and numbers of birds:

1. 19 pulli taken at the nest on the day of hatching (= Day 0).
2. 59 newly hatched pulli away from the nest, which we know or believe to be one–two days old (= Day 1.5).
3. A further 27 chicks have been caught at known ages between two and 21 days old.
4. Included in these 27 are nine chicks recaptured after known time intervals. Along with a further two recaptures of unknown-age chicks, these give us 11 direct figures for weight increments per day.
5. In addition to 9 fledglings of known age which are included in 3, we have caught 19 other fledglings that were only just flying. We assume that these were each 19 days old, when measured, for this analysis.

The mean mass and bill lengths were calculated for the samples of Day 0, Day 1.5 and Day 19 chicks (categories 1, 2 and 5). We then calculated the regression of mass and bill-length against age (in days) for the 27 known-age birds (category 3), and included the means (only) of birds of Day 0, Day 1.5 and Day 19. We did this to avoid swamping our samples of known-age birds with the very young and just fledged birds.

Table 1. Measurements of chicks of Common Sandpiper *Actitis hypoleucos*. Those measured on Day '0' were still in the nest. Day 1–2 chicks had left the nest; they were regarded as 1.5 days old in the analysis. Day '19' chicks are those which were newly fledged, but of uncertain precise age. Known-age chicks which had just fledged were 18–22 days old.

Age	Mass (g)			Bill length (mm)		
	X	SD	n	X	SD	n
Day '0'	8.70	0.10	17	9.20	0.79	10
Day 1–2	8.94	0.84	59	10.21	0.56	29
Day '19'	40.32	2.78	19	21.00	1.04	18
Day 18–22	39.67	2.05	9	20.50	0.89	9

Results

Mass

At hatching, Common Sandpiper chicks average 8.7 g. They barely grow in weight initially, being only 8.94 g at 1–2 days old (Table 1). At fledging they average 40.11 g, implying a growth rate of 1.65 day^{-1} over 19 days. The calculated regression (reduced major axis) is $y = 1.73x + 5.87$ (Pearson's $r = 0.96$, $t = 18.6$, d.f. = 29, $p < 0.001$). The direct measurements of weight-gain of individuals ranged from 0.67 to 1.86 g day^{-1} (mean 1.46, S.D. 0.43, n = 11). There are indications (Figure 1) that growth rates were slower over the first 3–4 days of life, as might be expected.

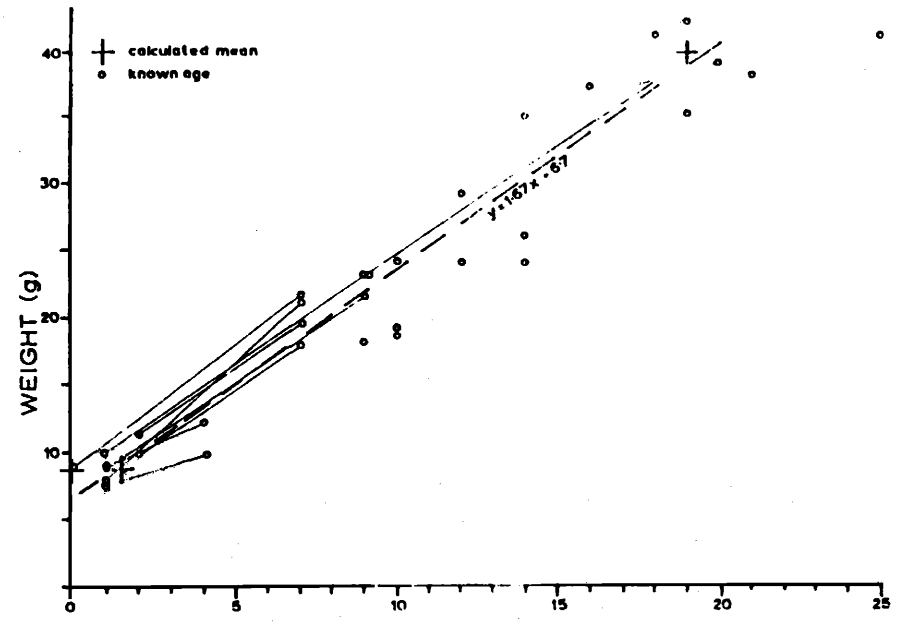

Figure 1. Mass (g) in relation to age (days) for Common Sandpiper chicks of known age. Solid lines connect points for each recaptured individual. The dashed line is the calculated (reduced major axis) regression line. The calculated means for chicks at hatching, at 1–2 days old, and at fledging are shown as crosses.

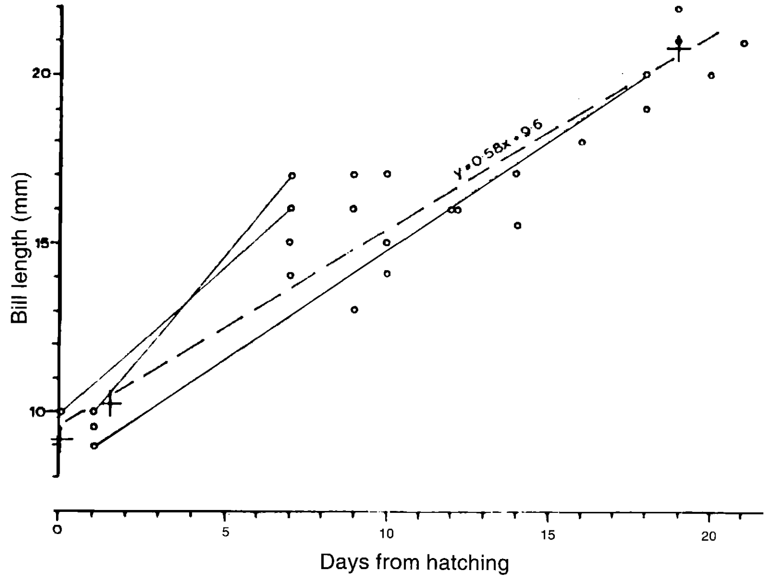

Figure 2. Bill-length (mm) in relation to age (days) for Common Sandpiper chicks of known age. Other details as Figure 1.

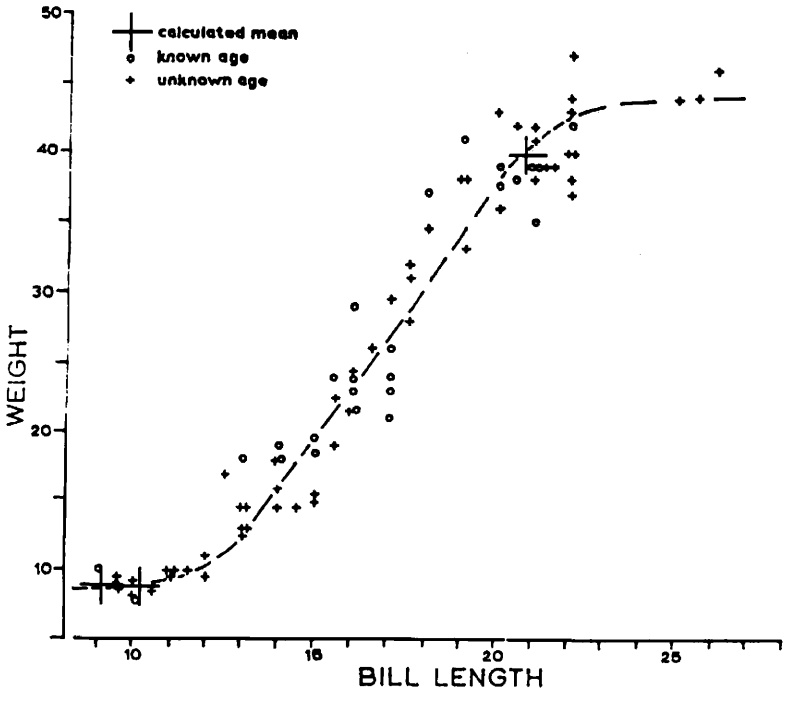

Figure 3. Graph of bill-length (mm) against mass (g), for all measurements of Common Sandpiper chicks, of known and unknown age. Trend line drawn by eye.

Bill length

At hatching the bills of Common Sandpiper chicks average 9.1 mm long, and by 1–2 days old these have increased to 10.2 mm long (Table 1). This increase is highly significant (t = 4.39, $p < 0.001$). At fledging bill-lengths average 20.83 mm, implying a growth rate of 0.61 mm day^{-1} over 19 days. The calculated regression is $y = 0.56x + 9.9$ (Pearson's t = 0.91, t = 10.8, d.f. = 23, $p < 0.001$) (Figure 2). There are insufficient recaptures of individuals to calculate a direct figure of daily growth rate, or to comment on any changes in growth rate, or to comment on any changes in growth rate with age.

Mass in relation to bill length

The possibility that bill-length might provide an estimate of age, independent of mass, is examined in Figure 3, which includes data from additional chicks of unknown age. Figure 3 shows that bill-length increases during the first few days after hatching while body mass does not. Reference to Figure 2 suggests that bills lengthen about 2 mm over four days, while body mass barely increases at all. It also appears that, having fledged at around 40 g (Figure 1), their bills continue to grow to adult length ($\bar{x}$ 24.8; Prater *et al.* 1977) but little or no weight is gained for a further 10 days after fledging. At fledging their wings are still very short ($\bar{x}$ 92.9, S.D. 5.17, range 83–100 mm, n = 23) compared with those of adults (male $\bar{x}$ 111.5, range 105–117, female $\bar{x}$ 115.7, range 111–122; Holland *et al.* 1982), and we presume that further growth over the 10 days post-fledging goes into increases in length rather than into mass.

Discussion

Visser & Beintema (1988) suggest that waders vary between slow-growing but energetically conservative species (e.g. Lapwing *Vanellus vanellus*) and fast-growing but energetically extravagant species (e.g. Black-tailed Godwit *Limosa limosa*). In growing at 1.65 g day^{-1} (3% of adult weight per day) and fledging in 19 days, Common Sandpipers seem to belong in the second group. This is also consistent with field observations that very little brooding is done after the first four days (Yalden 1986).

Green (1984) suggested that bill-length could provide a good estimate of age and that it might also allow the relative condition of a wader chick to be assessed. It certainly appears that bill-length is a better indicator of age over the first four days of life than is mass and this is probably true after fledging as well. Figure 3 indicates that in the middle period of chick growth, when bills measure between 12 mm and 20 mm (equivalent to ages around four to 20 days – Figure 2), the bill-length and mass are well correlated and so their relative values should give a useful indication of the chick's condition. Over this range of bill-lengths, the (reduced major axis) regression is y = 3.88x – 37.98 (Pearson's r – 0.97; t = 21.0; p < 0.001).

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Predicting the hatching dates of Curlew *Numenius arquata* clutches

MURRAY C. GRANT

RSPB, The Lodge, Sandy, Bedfordshire SGI9 2DL, UK

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The number of days to hatching was highly correlated with an index of egg density in four study populations, the index of egg density being obtained from measurements of egg length, breadth and weight. Regression equations of days to hatching against the index of egg density did not differ significantly between study areas, whilst the overall equation predicted days to hatching with a mean error of approximately two days.

Introduction

During studies of breeding waders it is useful to be able to predict the hatching dates of nests under study since the chicks of many species leave the nest within a day or two of hatching and thereafter become extremely difficult to find and therefore ring or fit with radio-tags. The option of visiting nests throughout the incubation period with sufficient frequency to ensure that successful hatching is confirmed is often impossible (due to time constraints) and may not be desirable since such frequent visiting may increase the possibility that observer activities will influence the outcome of the nesting attempts. Since egg density decreases during incubation (Rahn & Ar 1974) it is possible to produce regressions between days to hatching and an index of egg density based upon measurements of egg length (L), breadth (B) and weight (W) – i.e. W/LB^2. Such equations have been produced for several wader species, including Redshank *Tringa totanus,* Snipe *Galllnago galllnago,* Lapwing *Vanellus vanellus* and Black-tailed Godwit *Limosa lapponica,* and these allow prediction of hatching dates from the relevant egg measurements (Green 1984; Galbraith & Green 1985). Equations have been obtained from different study populations of Lapwing and Redshank which have demonstrated inter-population variation in patterns of egg weight loss with time to hatching for Lapwing (Galbraith & Green 1985) but not for Redshank (Green 1984). In this note data are presented on the relationship between days to hatching and the egg density index (W/LB^2) for Curlew *Numenius arquata* from four different study populations.