account the coverage of the areas and current knowledge of the area of suitable habitat present for various wader species.

It should be stressed that a complete wader census of the extensive mangrove areas of the Sine-Saloum Delta and the Casamance has never been carried out, so that the figures presented in Table 1 are tentative estimates.

REFERENCES

Altenburg,W. & van der Kamp,J. 1986. Oiseaux d'eau dans les zones humides de la Mauretanie du Sud, du Senegal et de la Guinee-Bissau; octobre-decembre 1983. Ned. Sticht. v. Intern. Vogelbesch./RIN-Contr. 86-1. Leersum, The Netherlands.

Altenburg,W., Engelmoer,M., Mes,R., & Piersma,T. 1982. Wintering waders on the Banc d'Arguin, Mauritania. Stichting Veth tot steun aan Waddenonderzoek, Leiden.

Altenburg,W., Engelmoer,M., Mes,R. & Piersma,T. 1983. Recensement des limicoles et autres oiseaux aquatiques au Banc d'Arguin, Mauritanie. *Gerfaut* 73: 243-264.

De Ridder,M. 1977. Observations d'oiseaux en Basse Casamance. *Biol. Jb. Dodonaea* 45: 84-103.

De Smet,K. & Van Gompel,J. 1979. Wader counts at the Senegalese coast in winter 1978-1979. *Wader Study Group Bull.* 27:30.

De Smet,K. & Van Gompel,J. 1980. Observations sur la cote senegalaise en decembre et janvier. *Malimbus* 2: 56-70.

Dupuy,A.R. 1976. Reproduction de Flamants roses (*Phoenicopterus ruber*) au Senegal. *Oiseau* 46: 294-296.

Dupuy,A. & Verschuren,J. 1978. Note sur les oiseaux, principalement aquatiques, de la region du parc national du Delta du Saloum (Senegal). *Gerfaut* 68: 321-345.

Zwarts,L. 1988. Numbers and distribution of coastal waders in Guinea-Bissau. *Ardea* 76: 42-55.

Peter L. Meininger, Belfort 7, 4336 JK Middelburg, The Netherlands.

ESTIMATING THE DATE OF HATCHING OF EGGS OF GOLDEN PLOVER *PLUVIALIS APRICARIA*

D. W. Yalden & P. E. Yalden

INTRODUCTION

Because they are nidifugous, wader chicks are usually ringed in the nest within a day of hatching. It is useful, therefore, to be able to predict the date of hatching of a nest found at some unknown date through incubation. We have found enough nests of Golden Plover in the last three years, and followed them through to hatching, to allow a reasonable prediction of hatching date to be made.

METHODS

All nests (24) were found in the Peak District, in northern England, between 1986 and 1988. On discovery of a nest, length and breadth of each egg was measured to 0.01 mm using Camlab plastic calipers, and weighed to 0.1 g with a 50 g Pesola balance. A Volume Index ($L \times B^2 \div 1\,000$, as per Byrkjedal & Kalas 1985) was calculated for each egg, and the mean weight and Volume Index for each clutch then calculated. These means were used to calculate a Density Index (weight ÷ Volume Index). Most nests (21) were followed through to hatching, and the date on which the measurements had been taken was then expressed as the number of days before hatching.

A few clutches were reweighed later in incubation, and these allow a direct estimate of the rate of loss of weight. The regression of 'Density Index' on 'Date of Hatching' was calculated, but without using these re-weighings. Because both the date to hatching and the weight (as taken under field conditions) were subject to error and approximation, the regression used was the reduced major axis.

RESULTS

Egg dimensions and densities are summarised in Table 1. Density indices were calculated for 21 clutches which were followed through to hatching. The regression is shown in Figure 1, together with the calculated values for day -30

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

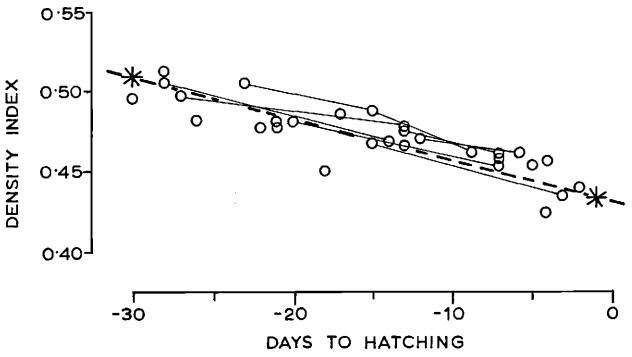

Figure 1. Density index (Weight/Volume Index) for 21 clutches of Golden Plover *Pluvialis apricaria* eggs in relation to date to hatching. The asterisks indicate calculated values for days -30 and -1 and the heavy dashed line is the calculated regression y = -389x + 168. Thin lines join values for clutches that were re-weighed during incubation.

(the start of incubation: Nethersole-Thompson & Nethersole-Thompson 1986) and day -1 (by which time the eggs are chipping, making calculation of hatching date superfluous). The calculated regression is $y = -389x + 168$ ($r = 0.86$, $p < 0.001$) where y = date before hatching and x = density index. Golden Plover eggs at the start of incubation should have a relative density of 0.509. By day -1 this has reduced to 0.434 (if chipping has not reduced it further).

The absolute loss rates varied between 0.095 and 0.19 g/day, or between approximately 0.3 and 0.6% of egg weight per day. Averages, from eight determinations, were 0.15 g/day (S.D. 0.036) and 0.47% per day (S.D. 0.17). Thus over 30 days of incubation, a Golden Plover egg loses an average of 4.5 g, or 14.0% of its initial weight. These values are close to the loss rate of 0.17 g/day calculated from the regression equation.

DISCUSSION

Rahn & Ar (1974) argued that weight loss of eggs during incubation was entirely due to loss of water. They further suggested that the proportion of the weight loss might be relatively constant across a taxonomically wide range of birds at around 18%. The figure of 14% is low by this standard. One interesting detail of our study is that in one clutch 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 process, 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 different 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 of hatching to be predicted, and visits every 2-3 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 x 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

We thank the Nature Conservancy Council for financial support through contract HF3-03-339 for our Golden Plover studies.

REFERENCES

Byrkjedal,I. & Kalas,J. 1983. Seasonal variation in egg size in Golden Plover *Pluvialis apricaria* and Dotterel *Charadrius morinellus*. *Ornis Scand.* 16: 108-112.

Nethersole-Thompson,D. & Nethersole-Thompson,M. 1986. *Waders: their breeding, haunts and watchers*. T. and A.D. Poyser, Calton.

Rahn,H. & Ar,A. 1974. The avian egg: incubation time and water loss. *Condor* 76: 147-152.

D.W. and P.E. Yalden, Department of Environmental Biology, The University, Manchester M13 9PL, U.K.