AN ANALYSIS OF NESTING SUCCESS AND HATCHING SUCCESS IN A LAPWING POPULATION

by Christopher P.F. Redfern

(reprinted, with revisions, from Edinburgh Ringing Group Report 9, 1981)

The recent interest in the distribution of breeding waders in Britain (e.g. see WSG Bull. 30, 1980) reflects increasing concern over the effects of intensive farming (Green 1980, Cadbury & Housden 1982). In addition to monitoring changes in breeding wader populations and suitable habitats, much needs to be learnt of the habitat requirements of individual species. Detailed breeding-biology studies of local wader populations are therefore of value. Estimates of nesting success, an important parameter in any ecological model, are frequently given in breeding-biology studies but are often based on inappropriate methods. Since its inception, the 'Mayfield method' (Mayfield, 1961, 1975) has been developed and refined by various authors and represents a simple, but soundly-based, method of estimating nest success. This analysis of modest data on breeding Lapwings *Vanellus vanellus*, collected during a study of habitat use, should be of use as a summary and illustration of the Mayfield method and its application.

Methods

The study area contained a variety of different habitats (Redfern 1983). Nests were located by searching for incubating birds from roadside watch points and were subsequently watched as often as possible. Towards the end of the incubation period, nests were visited approximately every two days to determine the number of eggs hatching successfully, and to ring the chicks. Eggs that failed to hatch (and were no longer being incubated) were opened for examination. The study was carried out in 1981.

Results and discussion

(i) Nest success

48 nests were found in 1981. The majority of these held completed clutches and only four nests were found during the laying period. The eventual outcome of 37 of these nests was known. Success or failure was based on the following criteria: a nest was successful if young were present in the nest or within 10-15 yards of the nest. A nest was judged to have failed if it was found empty only part-way through the incubation period. In determining the time of failure of a nest, it was assumed that a nest was in use if a Lapwing was sitting on the nest, and that a nest had failed if no bird was sitting on it during that, and subsequent, days. All nests thought to have failed were visited to check that this was so. With precocial birds, it is difficult to determine whether an empty nest represents a failed (predated) nest or one in which young have hatched and then moved some distance away, unless the time at which incubation started is known, or estimated by egg density (Furness & Furness 1981) or other criteria. Such methods were not used in this study and the outcome of 11 of the nests, for which the start of incubation could not be determined, was unknown.

Mayfield (1961, 1975) pointed out that estimates of nest success based merely on the proportion of nests which are successful may be biased unless only those nests found at the start of incubation are considered. To avoid this problem, Mayfield expressed nest failure as the number of losses per 'nest-day'. The 'exposure' of a particular nest is the time (in days) elapsed between its finding and loss (failure) or success (hatching, in the case of precocial birds). For a group of n nests, the failure rate per nest-day is the number of losses (f) divided by the total exposure (o) for all n nests (failure rate = f/o per nest day). This represents the maximum likelihood estimate of the failure rate per nest-day (Hensler & Nichols 1981), and in this example it is assumed that the probability of failure is approximately constant throughout the incubation period (see Willis 1981).

Mayfield (1961, 1975) explicitly stated that this method allows the use of all data available, including data (the number of nest-days) for those nests for which the start of incubation and the outcome are unknown. However, to include data for such nests would be treating these nests as if they were successful and the success rate per nest-day overestimated as a consequence. Thus, in any nest-success study it is important to determine the outcome of as many nests as possible. In this context, Pienkowski (1983) pointed out that BTO nest-record cards are of little use for estimating nesting success because of the large proportion of nests with unknown outcome.

To analyse the Lapwing data, I have therefore excluded 6 nests visited only once, and the five other nests whose outcome was unknown. Of the remaining 37 nests, 10 failed (predated?) and 27 hatched at least one chick successfully. These 37 nests were 'exposed' for 689 nest-days. Correcting for half a day for each failed nest, to take into account the fact that failure is unlikely to coincide with the time of a visit (Willis 1981), the rate of loss is 10/684 or 0.0146 per nest-day (success rate is 0.9854 per nest-day). Formulae for calculating confidence limits have been independently derived by Johnson (1979) and Hensler & Nichols (1981). These formulae are equivalent: Johnson's formula may be reduced to give that of Hensler & Nichols. Variance is estimated by: $r(1-r)/o$ (from Hensler & Nichols 1981) where 'r' is the success rate per nest-day and 'o' is the total exposure. For my Lapwing population, 95% confidence limits using the standard normal distribution are ±0.0092. Assuming an incubation period of 26 days (based on Witherby *et al* 1941) the overall success rate is $(0.9854)^{26}$ or 68.2% (95% confidence range 53.5% - 86.9%).

(ii) Hatching success

The mean clutch size of the 27 successful nests was 3.85 at the time of finding (n=27, S.D.=0.45) whereas the mean brood size at or soon after hatching was 3.22 (S.D. 0.85). This reduction in brood size was due to three causes: infertility, egg loss during incubation and embryonic death before or during hatching (Table 1). Eggs were scored as infertile if there was no sign of embryonic development; 'egg loss' is defined as the disappearance of an egg from the nest during incubation and may be due to predation, damage by livestock or displacement from the nest. 4.8% of eggs were infertile and a further 2.9% died as late embryos.

Table 1: Clutch sizes and the reduction in brood size at hatching

	Clutch size at the time of finding				
	2	3	4	5	eggs
Number of nests	2	11	34	1	
Nests with:					
1 infertile egg	0	0	5	0	
1 partly developed embryo	0	1	2	0	
Nests losing:					
1 egg	0	1	3	1	
3 eggs	0	0	1	0	

Two nests are represented in more than one category: one nest had one infertile egg and also lost an egg during incubation; another nest contained one infertile egg and an egg with a dead embryo.

The rate of loss (as defined above) of individual eggs from nests (as opposed to the loss or failure of entire clutches) may be estimated in the same way as the rate of nest loss. At each visit to a nest, the number of eggs was noted. An egg present for one day represents one 'egg-day'. The outcome of each nest with eggs is now unimportant and, of the original 48 nests, the data for the 37 nests of known outcome and five nests of unknown outcome can be utilised. Eight egg losses occured out of 2,403 egg-days (only eggs known to be present are included in the total eggs days), representing a loss rate of 0.0033 eggs per day, or a survival probability of 0.9967 per day. The survival probability for an individual egg is 0.918 over a 26-day incubation period (this does not take into account egg loss during the laying period).

The number of eggs in a nest at the start of incubation is a useful and exact definition of clutch size. In this study, the mean number of eggs per nest at the time of finding was 3.71 (n=48). How good is this as an estimate of initial clutch size? The mean observation time (exposure) of successful nests was 20 days per nest. Assuming an incubation period of 26 days, these nests were therefore found after a mean of 6 days incubation had elapsed. If this was true of all nests found, the egg loss over this period may be estimated and the clutch size estimate corrected accordingly. 4 eggs may have been lost over this period (from the success rate per egg-day) and the clutch size estimate corrected to 182/48 or 3.8 eggs per nest. This estimate of clutch size (noting that such estimates are poor substitutes for hard data) is identical to that of Jackson & Jackson (1975) for birds nesting in Hampshire.

The small amount of data available from this study inevitably limits the sophistication of the analysis. With larger samples, the Mayfield method can be used to look in greater detail at differences in failure rates in different populations, at different times of year and so on (Willis 1981). It would also be of interest to compare rates of individual egg loss, infertility and embryonic death between populations.

References

Cadbury,C.J. & S.Housden. 1982. Outer Hebrides - threat to breeding waders. Wader Study Group Bull. 35:5.

Furness,R.W. & B.L.Furness. 1981. A technique for estimating the hatching date of eggs of unknown laying date. Ibis 123: 98-102.

Green,G.H. 1980. Changing agricultural practice: Scotland and breeding waders. Wader Study Group Bull. 29:5.

Hensler,G.L. & J.D.Nichols. 1981. The Mayfield method of estimating nesting success: a model, estimators and simulation results. Wilson Bull. 93: 42-53.

Jackson,R. & J.Jackson. 1975. A study of breeding Lapwings in the New Forest, Hampshire 1971-1974. Ringing & Migration 1: 18-27.

Johnson,D.H. 1979. Estimating nest success: the Mayfield method and an alternative. Auk 96: 651-661.

Mayfield,H. 1961. Nesting success calculated from exposure. Wilson Bull. 73: 255-261.

Mayfield,H. 1975. Suggestions for calculating nest success. Wilson Bull. 87: 456-466.

Pienkowski,M.W. 1983. Breeding biology and population dynamics of Ringed Plovers Charadrius hiaticula in Britain and Greenland: nest predation as a possible factor limiting distribution and timing of breeding. J. Zool., Lond. 202: in press.

Redfern,C.P.F. 1983. Lapwing nest sites and chick mobility in relation to habitat. Bird Study 29: 201-208.

Willis,E.O. 1981. Precautions in calculating nest success. Ibis 123: 204-206.

Witherby,H.F., F.C.R.Jourdain, N.F.Ticehurst & B.W.Tucker. 1941. The Handbook of British Birds. H.F. & G. Witherby, London.

C.P.F.Redfern, 66 Highfield Avenue, Appleton Park, Warrington, Cheshire, WA4 5DX.

AN UNCERTAIN FUTURE FOR BREEDING WADERS IN ICELAND

by R.W. Summers and M. Nicoll

Many of the species of waders which visit Britain, either during migration or to winter on the coast, breed in Iceland. It is generally felt that those birds which breed in northern, sparsely populated, lands are relatively safe from the influences of man. Such a notion is far from the truth. Many waders which breed in Iceland do so in marshes, a threatened habitat.