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A COMPARISON OF TWO METHODS TO ASSESS THE BREEDING SUCCESS OF RING-BILLED GULLS

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The reproductive success of Ring-billed Gulls (*Larus delawarensis*) is usually calculated with data obtained from multiple visits to colonies throughout the breeding season (e.g., Vermeer 1970, Chamberlain 1973, Dexheimer and Southern 1974, Chardine 1978, Haymes and Blokpoel 1978, Somppi 1978). Another method, necessitating only a few visits made at different times, is also used to assess the reproductive success of other colonial birds; Nisbet and Drury (1972) used it with Common (*Sterna hirundo*) and Roseate (*Sterna dougallii*) terns, Kadlec and Drury (1968) and Weseloh et al. (1979) with Herring Gulls (*Larus argentatus*).

While studying Ring-billed Gulls in southern Quebec during the 1979 breeding season, both the multiple visit method and the planned visit method were used to test the efficiency of the latter. In this paper we describe the planned visit method, offer a comparison with the multiple visit method, and discuss their field of application.

STUDY AREA AND METHODS

Data were collected on Lefebvre and Petite Colonie islands, small islands 100 m apart lying off Contrecoeur, 35 km east of Montreal; they are part of the Contrecoeur National Wildlife Refuge. The soil is made up of clay covered by herbs dominated by black mustard (*Brassica nigra*) accounting for 70% of the cover in early July. In 1979 the eastern end of Lefebvre Island supported 2700 pairs of Ring-billed Gulls; 3000 nests were built on Petite Colonie Island.

Circular enclosures were set up using wire netting held in place with rods and pegs. The net was 76 cm high, some having a 25 mm mesh, others a more rigid 13 mm mesh. Enclosures were at least 10 m apart in order to minimize disturbance in those enclosures when a nearby one was being visited.

Multiple visit method.—The multiple visit method was used in three enclosures located centrally in the colony of Petite Colonie Island. Each measured 39.27 m^2; two had a 13 mm mesh and the other the 25 mm mesh. From 23 April to 20 July 1979, enclosures were usually visited every 2 days; windy and rainy days were avoided.

Each of the 40 visits to an enclosure did not last more than 45 min. Nests were identified with numbered tongue depressors, eggs were numbered in laying sequence with a non-toxic water color marker, and chicks were banded with aluminium bands. Data collected at each visit included records of new nests, eggs, chicks, missing eggs and chicks, and deaths.

Planned visit method.—The planned visit method was used from 17 May to 4 July 1979 on Lefebvre Island in 3 enclosures located centrally

in the colony. Two enclosures measured 39.27 m^2 and the other 78.54 m^2; the 3 had a 13 mm mesh. The planned visit method required only 3 visits, synchronized with the peaks in laying, hatching, and fledging. The visits lasted from 30 to 60 min. If the laying peak had not yet been reached on the first visit, when the enclosures were set up, it would have been desirable to return a few days later to census nests and eggs.

The first visit was made just before hatching began, when more than 75% of the nests contained 3 eggs. During that visit, nests containing at least one egg were numbered, and eggs were marked, as described above. These nests and eggs made up the study sample.

The second visit occurred 25 days after the first; the intervening period is equal to the mean incubation period of the third egg (Vermeer 1970, Nol and Blokpoel 1983). Most of the eggs marked on the first visit had hatched. Unhatched and non-addled numbered eggs, as well as new nests and new eggs laid in nests marked on the first visit, were not included in the sample but were left within the enclosure. Unhatched numbered eggs and dead and live chicks were recorded. Live chicks were banded and dead ones removed. Thus, only eggs marked on the first visit and chicks encountered on the second visit made up the sample. The second visit was made in early morning in good weather to avoid mid-day high temperatures that Hunt (1972) assumed to be detrimental to chicks. In addition, enclosures were divided with boards to restrict chick dispersal and ensuing aggression. To hasten banding of chicks that tended to disperse, chicks awaiting banding were held in boxes. Each was released in the subdivided enclosure in which it was caught. The collected data enabled us to compute hatching success (dead + live chicks/total marked eggs), and egg mortality (numbered eggs found unhatched/total marked eggs).

The third and last visit occurred at fledging, 23 days after the second visit. Chicks banded on the second visit were then at least 23 days old. This fledging period is postulated by Chardine (1976) and is 2 days longer than that defined by Dexheimer and Southern (1974), and Somppi (1978). Most chicks actually fledge at the age of 31 to 35 days (Lagrenade and Mousseau 1981), but a fledging age of 23 days is adequate since, according to our data and those of Vermeer (1970), over 75% of chick mortality has already occurred (65% in the first 10 days). Unbanded chicks were excluded from the sample; dead and live banded chicks were recorded. As on the second visit, the enclosure was divided with boards to hasten the census. With these new data we were able to compute chick mortality, fledging success, and overall reproductive success. The chick mortality rate is equal to the proportion of banded dead chicks to the number of eggs laid. The fledging success per egg laid is equal to the proportion of laid eggs which produced chicks recorded alive on the third visit; the fledging success per egg hatched is equal to the proportion of hatched eggs which produced chicks recorded alive on the third visit. The total number of fledged chicks is equal to hatched

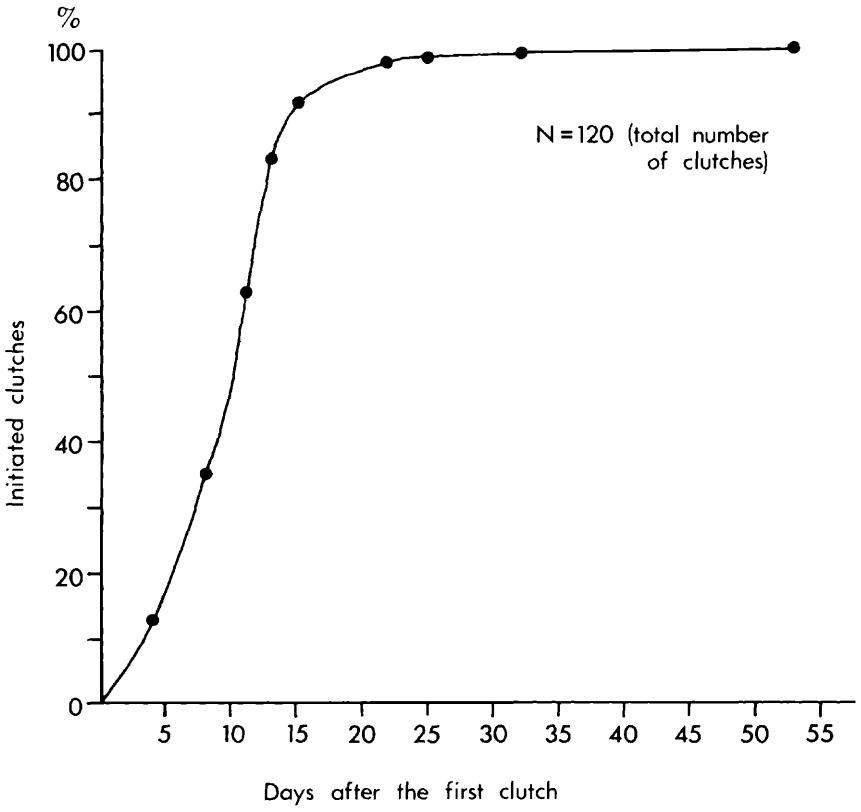

FIGURE 1. Phenology of clutch initiation of Ring-billed Gulls on Petite Colonie Island in 1979.

eggs minus dead chicks. Fledglings were at least 23 and no more than 48 days old (the period between the first and the third visit). The overall breeding success is equal to the number of chicks 23 days old and older divided by the number of nests marked on the first visit. At the end of this third visit the wire netting was removed.

Simulated planned visit method.—We also present the results obtained with a simulated planned visit method. These are the data obtained with the multiple visit method on the 3 days corresponding to the laying, hatching, and fledging peaks. It is thus a simulation of 3 planned visits in the enclosures which were actually visited 33 times before the third simulated planned visit.

Statistical treatment.—Clutch size data were examined with the *t*-test; other comparisons were done with the chi-square with Yates' correction factor (Sokal and Rohlf 1981).

RESULTS AND DISCUSSION

The colonies studied were highly comparable on account of (1) their simultaneous colonization by the gulls (Mousseau in press), (2) their great proximity, (3) their identical soil and vegetation composition, and (4) their similar breeding population.

Since the planned visit method required only a few visits at predetermined times, it was very important that the birds to be studied exhibit a strong reproductive synchrony. The gulls of Petite Colonie Island needed 9 days to initiate 72% of the clutches (Fig. 1).

For each method, the figures of Table 1 are combined data from the 3 enclosures. Nest density varied to some degree; however, reproductive success is apparently not related to nest density in Ring-billed Gulls (Dexheimer and Southern 1974, Fetterolf 1983). Clutch size did not differ significantly ($P > .05$) from one sample to another.

Hatching success.—A greater proportion of unhatched eggs disappeared with the planned and the simulated planned (77.8% and 79.8% respectively) than with the multiple visit method (57.4%). The multiple visit method allowed investigators to record in several instances the causes of egg mortality before their disappearance. In addition, clutches initiated and abandoned before the first visit, as well as eggs laid after the first visit which disappeared before the second, were not taken into account with the planned and the simulated planned methods. Those methodical differences are reflected by the significantly higher ($P < .01$) multiple visit method egg mortality than that of the simulated planned visit method (Table 1).

The hatching success was similar ($P > .05$) whatever the method used (Table 1). Although not significantly ($P > .05$) different than that of the multiple visit method, the higher simulated planned visit method hatching success is explained, as above, by the exclusion from the sample of eggs that died or disappeared before and after the first simulated visit.

We had expected that the multiple visit method hatching success would be lower than that of the planned visit method. Possible consequences of a high level of disturbance included: (1) frequent take-offs by incubators causing eggs to roll over the nests; and (2) extended periods without nest attendance increasing the risks of egg robbing and embryonic mortality due to excessive heating or cooling (Hunt 1972, Fetterolf 1983). Our results, however, did not show that increased disturbance had an adverse effect on hatching success.

Breeding success.—The different mortality rates of chicks were related to the different fledging ages inherent in the methods, and also to disturbance. With the multiple visit method, chicks 23 days old were considered fledged; afterwards, some of them died in the enclosures and others flew away when the investigators entered the enclosures (no chicks under 23 days disappeared from the enclosures where the multiple visit method was used). With the simulated planned visit method, chicks that flew away or that died before the third simulated visit were

TABLE 1. Comparison of the results obtained with the planned visit method (PVM), the multiple visit method (MVM), and the simulated planned visit method (SPVM) for various variables in breeding Ring-billed Gulls.

Colonies	Lefebvre Island	Petite Colonie Island		Statistical comparison between methods[a]		
Methods	PVM	MVM	SPVM	PVM/MVM	PVM/SPVM	MVM/SPVM
Nest density (nests/m²)	1.21	1.01	0.93			
Number of nests	193	120	109			
Clutch size	2.82 ± 0.45[b]	2.88 ± 0.48	2.89 ± 0.42	1.06	1.26	0.16
Number of eggs laid	545	346	315			
Egg disappearance (%)	19.3	14.4	16.2	3.09	1.07	0.26
Egg mortality (%)	5.5	10.7	4.1	7.47**[c]	0.53	9.25**
Chick mortality (%)	7.7	14.8	34.9	10.46**	99.74***	35.36***
Hatching success (%)	75.2	74.9	79.7	0.00	1.98	1.91*
Fledging success per laid egg (%)	67.5	60.1	44.8	4.76*	41.87***	14.99***
Fledging success per chick (%)	89.8	80.3	56.2	11.06***	97.26***	33.26***
Breeding success (fledglings per nest)	1.91	1.73	1.29			

[a] Statistical methods: *t*-test for clutch size and chi-square with Yates' correction factor for continuity.

[b] SD.

[c] * $P \leq .05$; ** $P \leq .01$; *** $P \leq .001$.

considered dead. Therefore, the higher simulated planned visit method chick mortality (34.9%) than that of the multiple visit method (14.8%) reflected an over-estimation of the mortality of chicks 23 days old and older. On the other hand, the very highly significant ($P < .001$) higher simulated planned visit method chick mortality than that of the planned visit method was attributed to the disturbance caused by the high number of visits of the multiple visit method. Thus the multiple visit method caused a 27% increase of chick mortality or .8 chick per nest. Fetterolf (1983) documented the effects of human disturbance on the behavior and the reproductive performance of Ring-billed Gulls. He found that adult fighting, chick runs, and attacks on chicks were significantly higher in a moderately and a most disturbed plot (disturbance similar to that of the multiple visit method) than in a least disturbed plot (disturbance similar to that of the planned visit method). As a result, chick mortality increased with disturbance.

Consequently, the fledging successes of the planned visit method were significantly higher than those of the multiple and the simulated planned visit methods. The planned and the simulated planned visit figures for fledging success per chick (89.8% and 56.2% respectively) were nearly identical to those found by Fetterolf (1983) in a least- and a most-disturbed plot (95% and 57% respectively). The planned visit overall breeding success (1.91; Table 1) was higher than that obtained by most authors (Vermeer 1970, Somppi 1978, Emlen 1956, Ludwig 1966, Dexheimer and Southern 1974, Chardine 1976, 1978, Haymes and Blokpoel 1978).

The impact of enclosures.—As did Pearson (1968), we found that enclosures did not adversely affect laying and incubating behavior of breeding gulls. But since adult gulls usually stop feeding their young at fledging (Vermeer 1970), it is possible that some chicks died in the enclosures, too old to be fed by their parents. More notable and more variable effects on fledglings were related to the different wire nettings. Many fledglings pushed their bills through the mesh, wounding themselves at the base of the maxilla. In the 2 enclosures with the 13 mm mesh where the multiple visit method was used, 9 fledged chicks were found dead with the bill areas much infected; 6 of them died before the third simulated visit (these represented only 2.4% of the total chick population). We noted no severe wounds in the enclosures with the 25 mm mesh and neither did Nisbet and Drury (1972) in their study. In previous studies we found that the more flexible 25 mm mesh could sag, especially when held in position by an insufficient number of rods, allowing some fledglings to climb over the enclosures. This behavior was not noted with the more rigid 13 mm mesh. Enclosure area had no effect on the reproductive performance: breeding success in the large enclosure (planned visit method) equalled or surpassed that of the small enclosures. However, it may be preferable to use small enclosures since shorter visits presumably reduce disturbance.

Comparison with methods used by other authors.—The planned visit meth-

od differs from the one used by Nisbet and Drury (1972) in that it does not necessitate a visit when chicks are 10 days old nor does it depend on the capture-recapture method to count chicks at the fledging peak. In addition, the planned visit method only surveys eggs marked on the first visit and chicks banded on the second; this definite sample prevents an over-estimation of various successes brought by the inclusion in the results of unmarked eggs and chicks.

As for the methods used by Kadlec and Drury (1968) and by Weseloh et al. (1979), which are almost identical to the planned visit method, these involved Herring Gulls. The colony size and nest density of this species are usually lower than those of Ring-billed Gulls, whose study is almost impossible without enclosures. Their methods are speedy (only 3 visits) and reduce disturbance. However, that method yields figures only for breeding success and none for hatching success and egg mortality. Moreover, if that method was used with Ring-billed Gulls, the first visit at the end of incubation would occur when an important proportion of eggs had already hatched (Lagrenade and Mousseau 1981). Finally, using capture-recapture to count live chicks only allows for an approximation of total chick population, assuming that chick detectability is identical during both surveys. With these factors combined, the breeding success obtained is only an approximation and the method is less likely to detect variations in breeding success.

Fields of application.—The multiple visit method yields accurate data on breeding biology (egg and chick mortality), thus reducing the rate of unaccounted for disappearance. But these data largely reflect the influence of a high level of disturbance rather than the true reproductive performance (see also Fetterolf 1983).

The planned visit method is less expensive and causes minimal disturbance; it under-estimates hatching and fledging successes but, provided an adequate number of enclosures is used, it yields enough information to ensure the detection of variations of the various measurements of breeding success during short-term or long-term studies, as well as the influence of different environmental conditions in various colonies studied during the same season. However, the potential for meaningful biological interpretation may be rather limited in some circumstances.

SUMMARY

This paper describes a method of assessing the breeding success of Ring-billed Gulls that requires only 3 or 4 visits planned to coincide with the main events of the breeding cycle; it is thus less expensive than the standard method with multiple visits and reduces the disturbance caused by repeated visits to colonies. The results for breeding successes, although higher than those obtained using the standard method, are nonetheless under-estimations. Somewhat less accurate than the standard method in some respects (variable fledging age: 23 days and more; higher unaccounted for disappearance rate), the method enables one

to compute the various breeding successes while reducing the disturbance caused by the standard method: a chick mortality as high as 27% of the eggs laid. The results obtained with this method are closer to the true reproductive performance than those of the standard method which largely reflect the influence of a high level of disturbance.

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