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INCIDENCE, CLUSTERING, AND EGG FERTILITY OF LARGER THAN NORMAL CLUTCHES IN GREAT LAKES RING-BILLED GULLS

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Clutches with 5–7 eggs which usually result from female-female pairs or polygynous associations have been found in colonies of Western (*Larus occidentalis*) (Hunt and Hunt 1977), Ring-billed (*L. delawarensis*) (Conover et al. 1979a, Ryder and Somppi 1979), California (*L. californicus*) (Conover et al. 1979a) and Herring gulls (*L. argentatus*) (Shugart 1980). Normally, the maximum clutch size in gulls is 3. Occurrence of 5–7-egg clutches has been reported from the west coast of the United States (Hunt and Hunt 1977, Conover et al. 1979a), from Lake Winnipegosis in Manitoba (Koonz 1980), from Lake Superior (Ryder and Somppi 1979) and Lake Huron (Southern and Southern 1981). Since Ryder and Somppi (1979) and Southern and Southern (1981) each reported 5–7-egg clutches from only 1 colony on the Great Lakes, we felt it would be valuable to determine the extent of the phenomenon elsewhere in the Great Lakes. We recorded the incidence of 5–7-egg clutches at Ring-billed Gull colonies on the Great Lakes. We also recorded the frequency of 4-egg clutches at these colonies since such clutches are larger than the normal maximum and may result from female-female pairs (Hunt and Hunt 1977) or nest parasitism (Conover et al. 1979a).

During censuses of breeding Ring-billed Gulls in previous years, we had noticed that clutches with more than 3 eggs (hereafter large clutches) often seemed to occur in discrete clusters, i.e., they were spatially clustered within a colony compared to normal clutches. Here we report data which bear on these observations.

Ryder and Somppi (1979) reported that eggs in 5–7-egg Ring-billed Gull clutches had low fertility [65 (49%) of 127 eggs examined had embryos or had hatched] whereas Conover et al. (1979a) found substantially higher fertility (65–70%). We wanted to determine if Ryder and Somppi's (1979) data were typical of the Great Lakes population of Ring-billed Gulls, so we determined egg fertility in 4- and 5–7-egg clutches from several colonies.

METHODS

In May and June 1980, we surveyed 51 colonies of Ring-billed Gulls on lakes Erie, Ontario, and Huron and censused nests by placing brightly-colored tapes 5–10 m apart and counting each active nest while we walked the delimited strips. An active nest contained eggs or chicks or was composed of a trampled nest platform with excrement. We censused most colonies late in the incubation period and analyzed only data from colonies where less than 1% of the nests had chicks.

Our definition of "colony" follows Gochfeld (1980) and refers to a

TABLE 1. Incidence of 4- and 5–7-egg clutches in surveyed colonies in 1981 by geographic area.

Location	Colony	No. nests	% 4-egg clutches	% 5–7-egg clutches
St. Lawrence River	Strachan I.	9,829	1.93	0.12
Ottawa River, Ottawa	Unnamed I.	403	4.22	1.24
W. Lake Ontario	Eastern Headland	66,528	0.82	0.01
Niagara River	Tower I.	1,808	3.82	0.17
E. Lake Erie	Canada Furnace	27,575	1.66	0.09
Lake Huron	(46 colonies)	74,202	0.98	0.31
Total		180,344	1.01	0.17
E. Lake Superior	Vrooman I.[a]	168	10.70	30.40
E. Lake Superior	Agawa Rocks[b]	54	5.56	1.85
W. Lake Superior	Granite I.[c]	1,911	—	1.94
Total		2,133	9.46	4.17

[a] Data from 1978.
[b] Data from 1979.
[c] Data from Ryder and Somppi (1979).

nesting aggregation which is separated from another so that behavioral interactions among individuals from different breeding groups is severely restricted or absent. A subcolony is a group of breeding individuals separated from other nesters by a local geographic discontinuity such as open space, vegetation, or water (Gochfeld 1980).

We used the following procedure to determine whether large clutches were clustered: For each large clutch in 4 colonies we recorded the absence/presence of a large clutch in the nests of any of the nearby neighbors. We consider 2 nests to be nearby neighbors if the imaginary "corridor" between the outer edges of the respective nesting structures was free of other gull nests and if the 2 nests were less than 3 m apart. The most common form of clustering was "pairs" of large clutches, i.e., 2 nests that were nearby neighbors and had more than 3 eggs each. We infrequently found 3 large clutches distributed in a straight line (lines) or a triangle (trios). For the purposes of the analysis a 3-nest line of large clutches was arbitrarily considered as 2 "pairs" (1 and 2, 2 and 3) and a trio as 3 "pairs" (1 and 2, 1 and 3, 2 and 3).

To develop a method for statistically testing the observed degree of clustering, we used the following logic: in a sample of n nests, each of m large clutches has b neighbors. Under the null hypothesis of random distribution, a fraction $(m - 1)/(m + n - 1)$ is expected to be large clutches. Each pair of nearby neighbors is counted twice, so the expected number of large clutch × large clutch pairs has a Poisson distribution with mean $[m(m - 1)b]/[2(m + n - 1)]$. We then determined the probability that the observed number of large clutch × large clutch pairs could have arisen by chance.

TABLE 2. Incidence of 4- and 5–7-egg clutches by colony size from Lake Huron.

Colony size	No. nests (colonies)	4 eggs		5–7 eggs	
		No.	(%)	No.	(%)
Small (<1000)	5,009 (26)	98	(1.96)[a]	27	(0.54)[a]
Medium (1000–3000)	14,778 (7)	228	(1.54)[b]	84	(0.57)[b]
Large (>3000)	54,415 (7)	401	(0.74)[a,b]	123	(0.23)[a,b]
Total	74,202 (40)	727	(0.98)	234	(0.32)

[a,b] Chi-square test, df = 1, P's < .005 for each type of large clutch between different-sized colonies. Figures with same superscripts and in the same column or row are significantly different from one another.

Using the method presented here for counting nearby neightbors, a sample of 41 pairs on Mugg's Island, Toronto, Ontario, Canada in 1978 (see Fetterolf 1981) had an average of 5.6 nearby neighbors (SD = 1.2). On the Eastern Headland, Toronto, Ontario (see Blokpoel and Fetterolf 1978) in 1982, 139 pairs had an average of 4.4 nearby neighbors (SD = 1.0). Both figures are high estimates of the number of nearby neighbors because they only include nests away from the fringe of the colony where the number of nearby neighbors is lower. Using 5.0 as our estimate of the average number of nearby neighbors, the number of expected neighbor-neighbor pairs with large clutches is therefore high and our analysis provides a conservative estimate of clustering.

To assess fertility we opened all eggs from large clutches at 7 colonies late during incubation when it was unlikely that many eggs were fresh or unincubated. Fertile eggs were those with a visible embryo (whether viable or not). We determined the minimum fertility of 3-egg clutches from a 3-year total of 5 study sites on the Eastern Headland by recording hatching success during 1980, 1982, and 1983. Hatching of eggs was determined by visiting nests (1980) or by observing nests with binoculars from a remote location (Fetterolf and Blokpoel 1983).

RESULTS

Incidence

Our calculated frequencies of 4- and 5–7-egg clutches are summarized by broad geographical area in Table 1. The Ottawa River and Lake Superior colonies had slightly elevated frequencies of large clutches especially in the 5–7-egg group. Vrooman Island (approximately 1.5 km from Agawa Rocks) in 1979 was truly aberrant with close to one-third of the nests containing 5–7 eggs. In 1980, there were no Ring-billed Gulls on Vrooman and only 1 pair nested on nearby Agawa.

Lake Huron.—The 46 surveyed breeding sites on Lake Huron had from 1 to 14,557 nests. Most were in Georgian Bay and the North Channel of Lake Huron, and all were situated between 45°11′ and 46°17′N and between 80°30′ and 83°51′W.

We determined whether the frequencies of 4-egg clutches paralleled those of 5–7-egg clutches. To test the correlation between the 2 "types"

of large clutches, we used only those colonies which had more than 200 nests. Inclusion of the smaller colonies without any large clutches would have given an unrealistically inflated correlation coefficient. Also, we excluded from the analysis all colonies where the majority of pairs were initiating nests, i.e., had nest scrapes with 0–2 eggs. From the remaining colonies, we found that the occurrences of 4- and 5–7-egg large clutches were positively correlated (Spearman rank correlation, $r = .66$, df = 24, $P < .01$).

Second, we investigated the relationship between colony size and the incidence of 4- and 5–7-egg clutches. We arbitrarily assigned colonies to 3 size categories depending on the number of nests (small <1000, medium 1000–3000, large >3000). As in the preceding analysis, we excluded all colonies with high frequencies of nest scrapes, but included colonies of all sizes. In the analysis of the 40 remaining colonies, we found that the frequency of 4-egg clutches was not greater in small colonies than in medium-sized ones ($\chi^2 = 3.70$, df = 1, $.05 < P < .10$, Table 2). However, the frequency of 4-egg clutches was greater in medium-sized colonies than in large colonies ($\chi^2 = 82.99$, df = 1, $P < .005$) and the same was true for small versus large colonies ($\chi^2 = 80.40$, df = 1, $P < .005$). Small- and medium-sized colonies had nearly equal frequencies of 5–7-egg clutches ($\chi^2 = .02$, df = 1, $P > .05$) and both were higher than the frequency in large colonies (small vs large—$\chi^2 = 16.68$, df = 1, $P < .005$; medium vs large—$\chi^2 = 44.54$, df = 1, $P < .005$).

Eastern Headland.—Although this Ring-billed Gull metropolis is considered as a single colony in Table 1, it actually consists of 7 subcolonies, somewhat separated geographically and having different colonization histories and nesting phenologies (Blokpoel and Fetterolf 1978, Table 3). Since 2 censuses were required to count all nests with eggs in each subcolony ("early" 9–19 May and "late" 9–16 June), we used these data to determine whether the occurrence of large clutches varied with time of nesting. The second census of nests with eggs in each subcolony was made at least 26 days after the first. Since the incubation period for Ring-billed Gulls is 25–28 days (Nol and Blokpoel 1983), it is unlikely that we counted the same nests twice. The frequency of 4-egg clutches was similar for early and late counts. However, late nests pooled for all subcolonies had a higher frequency of 5–7-egg clutches (0.12%) ($\chi^2 = 5.01$, df = 1, $P < .05$) than early nests (.05%).

We divided the Headland's subcolonies into 2 groups based on the number of years gulls have nested in each area. Areas A–D have supported breeders since at least 1976 (established subcolonies), whereas areas E–G have been inhabited since 1978 (recent subcolonies) (see Table 3). When we combined all 4- and 5–7-egg clutches, more large clutches were counted in recent subcolonies ($\chi^2 = 6.52$, df = 1, $P < .05$).

Spatial Clustering

The results of our observations on the clustering of large clutches are summarized in Table 3 and show that clustering was statistically significant in many cases. Clustering occurred most dramatically on early

TABLE 3. Observations on the occurrence of nearby neighbor pairs of larger than normal clutches.

Colony	Sub-colony	Total no. nests	No. of large clutches	No. of large × large clutches as nearby neighbor pairs	
Eastern Headland	A early	7,962	130	—	—
Eastern Headland	A late	454	9	2	$P < 0.001$
Eastern Headland	B early	18,877	168	12	$P < 0.02$
Eastern Headland	B late	770	0	0	—
Eastern Headland	C early	18,436	113	12	$P < 0.001$
Eastern Headland	C late	2,430	16	0	—
Eastern Headland	D early	9,964	71	—	—
Eastern Headland	D late	1,321	7	0	—
Eastern Headland	E early	3,771	46	10	$P < 0.001$
Eastern Headland	E late	1,967	25	2	$P < 0.04$
Eastern Headland	F early	117	0	0	—
Eastern Headland	F late	319	1	0	—
Eastern Headland	G early	90	1	0	—
Eastern Headland	G late	52	1	0	—
Strachan Island	B	315	4	0	—
Strachan Island	C	1,901	29	0	—
Strachan Island	D	310	4	1	$P < 0.02$
Strachan Island	E	6,664	154	10	$P < 0.12$
Tower Island		1,808	72	12	$P < 0.03$
Canada Furnace	West	17,979	301	20	$P < 0.02$

censuses at the Eastern Headland (censuses at other colonies correspond to early censuses). Clustering also occurred on late censuses in a relatively new, expanding subcolony (E) and an old subcolony (A).

Fertility

Minimum fertility (hatching success) in 3-egg clutches from the Eastern Headland was higher than fertility for 4-egg clutches ($\chi^2 = 24.3$, df = 1, $P < .005$) and 5–7-egg clutches ($\chi^2 = 64.23$, df = 1, $P < .005$) (Table 4). Egg fertility was higher in 4-egg clutches than in 5–7-egg clutches ($\chi^2 = 13.66$, df = 1, $P < .005$). However, fertility in the two 6-egg clutches was similar to 4-egg clutches.

DISCUSSION

Our data support the hypothesis that high frequencies of large clutches occur where nesting space is not limiting. The incidence of large clutches in our study is generally lower than the rates of occurrence reported by other authors [Hunt and Hunt 1977 (8–14%) with Western Gulls; Conover et al. 1979a (3.3%), Ryder and Somppi 1979 (1.9–12.1%), Koonz 1980 (4.5%) with Ring-billed Gulls]. An exception to this generalization is the Calcite colony on Lake Huron which had frequencies of large clutches comparable to those in our surveys (Southern and

TABLE 4. Fertility of eggs in 3–7-egg clutches.

Clutch size	Total no. eggs	No. eggs fertile	%
3	396	360[a]	90.9
4	236	180	76.3
5	40	21	52.5
6	12	9	75.0
7	7	0	00.0
Total	691	570	82.5

[a] Number of eggs that hatched.

Southern 1981). Our surveys indicated that higher incidences of large clutches occurred in colonies with fewer than 3000 nests. The Calcite colony falls into our large colony group (Southern and Southern 1981), whereas colonies in the other studies of Ring-billed Gull large clutches fall into our small and medium size categories. In our study, the occurrence of unused nesting space at small- and medium-sized colonies suggests that competition for nest sites was probably low and that the colonies may have been recently established.

The Ring-billed Gull population of the Great Lakes has been expanding rapidly in recent years (Ludwig 1974, Blokpoel unpubl. data). The epicenter of the breeding range appears to be on Lake Ontario with an estimated 11 colonies accounting for approximately 50% of the nests on the Canadian Great Lakes (Blokpoel 1977, Blokpoel and McKeating 1978, Blokpoel et al. 1980, unpubl. data). We believe that colonies such as those on Lake Superior represent recent invasions of breeding sites on the edge of the expanding range. Notably, the Ring-billed Gull population studied by Conover et al. (1979a) was increasing dramatically during their investigation (Conover et al. 1979b).

Additional evidence from the Eastern Headland indirectly supports the hypothesis that large clutches occur more often in circumstances where competition for space is lower. Clustering of large clutches and the higher frequency of large clutches at recent subcolonies with unoccupied nesting habitat fits the hypothesis.

Ring-billed Gulls often nest in clumps (Vermeer 1970, Fetterolf 1981). Such behavior and an approximate 1:4 decrease in territory size concurrent with incubation tends to create spaces between the clumps particularly about 7–21 days after egg-laying begins (Fetterolf unpubl. data). Competition for these spaces may be reduced or absent (Fetterolf pers. obs.), so they provide opportunities for nesting by individuals that otherwise might not gain a nesting territory (e.g., female-female pairs). Since these open spaces may be available for a short time relatively early in the nesting chronology of any given nesting area (e.g., subcolony), the occurrence of significant clustering on early censuses at the Eastern Headland supports this argument. In addition, we found more 5–7-egg clutches during our late censuses on the Eastern Headland. Apparently

this occurred because lake levels receded after our first count and created open space at the edge of some subcolonies. The most striking example of large clutches in these new areas was discovered in the oldest subcolony (Area A), where we found five 4-egg clutches and four 5–7-egg clutches in 20 m of newly exposed beach. These nests accounted for the significant clustering on the late census in the subcolony. The frequencies of 4- and 5–7-egg clutches were significantly correlated in our census of Lake Huron colonies. This suggests that many 4-egg clutches may result from 2 females laying eggs in the same nest.

Egg fertility in 5–7-egg clutches in our study was similar to the levels reported by Conover et al. (1979a) but higher than the levels reported by Hunt and Hunt (1977) and Ryder and Somppi (1979). Perhaps a relatively greater local shortage of males (as sperm donors) accounted for the low fertility found by Hunt and Hunt (1977) and Ryder and Somppi (1979). In Herring Gulls, Red-billed Gulls (*L. novaehollandiae*), and Black-legged Kittiwakes (*Rissa tridactyla*), females tend to disperse from the natal colony more than males (Greenwood 1980). If Ring-billed Gull females also disperse more than males, a colony at the edge of the breeding range such as that studied by Ryder and Somppi (1978) may have a relative abundance of females. Our fertility data were gathered at large, persumably stable colonies (97% of clutches checked) where shortages of males are less likely.

SUMMARY

A survey of Ring-billed Gull colonies in the Canadian Great Lakes showed that 4- and 5–7-egg clutches were most abundant at small and medium-sized colonies (<3000 nests) and were significantly clustered in many cases. Egg fertility in 5–7-egg clutches was higher than in 2 previous studies. Our data support the hypothesis that high frequencies of clutches of 4–7 eggs occur at colonies where nesting space is not a limiting factor and where there is likely to be a shortage of males.

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