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NOTES

Impact of the Ring-Billed Gull (*Larus delawarensis*) on the Microbiological Quality of Recreational Water

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We evaluated the impact of the ring-billed gull (*Larus delawarensis*) on the microbiological quality of water. We measured fecal coliforms, *Salmonella* spp., and *Aeromonas* spp. in the gull droppings and the number of fecal coliforms in the water prior to and after attracting these birds to the beach with food. Gulls can contribute to the bacteriological degradation of recreational water.

Along the St. Lawrence river, there are several colonies of ring-billed gulls (*Larus delawarensis*) (4), and their population is growing rapidly in the city of Quebec. According to Canadian Wildlife Service surveys, the number of pairs in Quebec went from 1,400 in 1977 to 5,788 in 1985 and then to 21,714 in 1991. Such an increase gives rise to potential public health concerns. Among them is the possibility of disease transmission from fecal material (9). Quessy has shown that 8.71, 15.91, and 9.40% of the ring-billed gull population in the Montreal area were carriers of *Salmonella* spp., *Campylobacter* spp., and *Listeria monocytogenes*, respectively (24). Many other studies have recorded the presence of human and animal pathogens, mainly *Salmonella* spp. (3, 6–8, 10, 18, 19, 22, 30) but also *Campylobacter* spp. (18, 29) and *Yersinia* spp. (18), in the droppings of other gull species. These birds were also involved in several outbreaks of salmonellosis in animals (5, 16, 25). Humans can come in contact with gull fecal matter when swimming. The impact that these birds may have on the microbiological quality of recreational water has not been fully evaluated.

This paper documents the influence of gull droppings on indicator bacteria (fecal coliforms [FC]) in water and documents the concentrations of FC, *Salmonella* spp., and *Aeromonas* spp. in gull fecal matter.

In a first study, droppings were initially collected on 3 June, 18 June, and 8 July 1991 at the ring-billed gull colony site in the city of Quebec. Ten pieces of polyethylene (1 by 2 m) were spread out on the ground over the whole colony site, and at regular 15-min intervals, droppings were collected with scrapers and deposited in a sterile plastic jar. They were kept at 4°C and brought to the laboratory, where microbiological analyses were conducted within 12 h.

We carried out a second study on a 110-m public beach located on a 10,000-m^3 spring-fed lake in the area of the city of Quebec. The volume of water set aside for swimmers is 3,300 m^3. The beach was under surveillance during the summer of 1991, and the geometric mean of four groups of samples taken at regular intervals between early June and late August never exceeded 11 FC per 100 ml.

On 3 September 1991, no gulls were on the beach when the first water samples were collected (11:00 a.m. and 3:00 p.m.). We started attracting ring-billed gulls by spreading food on the beach at 3:00 p.m. Thereafter, food was provided continuously for 7 days. To quantify FC, water was taken along two parallel lines at the first and second thirds of the beach at depths of 0.3, 0.7, and 1.2 m (six samples per sampling) according to the directives issued by the Quebec Ministry of Environment (21). From 4 September to 10 September, the lake was sampled at different intervals (two to six times) between 9:00 a.m. and 7:00 p.m. Water temperature was measured at each sampling, and air temperature was recorded at 9:00 a.m., noon, and 5:00 p.m. daily. The precipitation was also documented. A naked-eye count of the gulls (beach and surroundings) was taken hourly between 9:00 a.m. and 7:00 p.m. every day.

FC were quantified in the droppings by the most-probable-number method with five tubes of EC broth, as recommended by the American Public Health Association (2). Samples were plated on MacConkey agar and brilliant green bile agar and identified with API 20E tests (API, Analytab Products, New York, N.Y.). *Salmonella* spp. were isolated by methods recommended by the U.S. Food and Drug Administration (28). Approximately 25% of these strains were sent to the Laboratoire de Santé Publique du Québec for serotyping. The *Salmonella* sp. count per gram of droppings was estimated by the five-tube most-probable-number method (2) with enrichment broths of selenite cystine and tetrathionate. The *Aeromonas* spp. were quantified by the technique developed by Palumbo et al. on starch-ampicillin agar (23). The FC count in the water was performed by membrane filtration, as recommended by the American Public Health Association (2).

Daily, for each of the depths (0.3, 0.7, and 1.2 m) as well as for the whole set of samples, we calculated the FC geometric means. We also determined, on an hourly basis, the mean number of birds present at the study site. The

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TABLE 1. Variations in bacterial concentrations in gull droppings[a]

Date	No. of droppings	Concn (CFU/g) of:		
		FC	Salmonellae	Aeromonads
3 June 1991	100	2.4×10^7	1.5×10^2	ND[b]
18 June 1991	148	1.1×10^6	2.3×10^2	5×10^6
8 July 1991	236	5.2×10^6	1.2×10^4	1.2×10^7

[a] Droppings were collected at the ring-billed gull colony in the city of Quebec.
[b] ND, not determined.

correlation between the numbers of FC and gulls was then examined by Spearman's correlation coefficients (r) (20).

Bacterial counts and the number of droppings collected during the three sampling periods of the first study are shown in Table 1. When the FC were identified, over 99% of the strains were *Escherichia coli*. Almost 200 strains of *Salmonella* spp. were isolated. Of these, 42 were serotyped. Seven serotypes that are potentially pathogenic in humans and animals, namely, *S. brandenburg* (12 isolates), *S. agona* (11 isolates), *S. hadar* (6 isolates), *S. stanley* (4 isolates), *S. anatum* (3 isolates), and *S. typhimurium* (2 isolates), were identified.

During the second study, little precipitation occurred (<5.2 mm/day) and the air and water temperatures remained stable (18 to 26°C and 20 to 24°C, respectively). It is unlikely that these variables influenced the FC concentrations in the water. Because of technical problems, analyses could not be done on 7 September. Once food was spread out on the beach (3:00 p.m. on 3 September), the number of birds increased rapidly (Table 2), as did the FC concentrations in the water, mainly in the shallower areas (0.3 and 0.7 m). The correlations between the logarithmic means of the FC concentrations measured each day and the number of birds, at three depths and for all the data, are shown in Fig. 1. The Spearman correlation coefficients were all statistically significant.

Although slightly lower, FC counts measured in the droppings of ring-billed gulls in this study were similar to those recorded by Gould and Fletcher for other gull species (7.1×10^7 bacteria per gram in herring gulls' droppings) (11). Fenlon (6) and Girdwood et al. (10) previously reported mean concentrations of 39.7 and 22.0 bacteria per gram of droppings among gulls. Initial counts obtained in our study were similar to those reported in Great Britain, but the third sampling revealed a much higher bacterial count. This could be explained by the presence of fledglings and immature

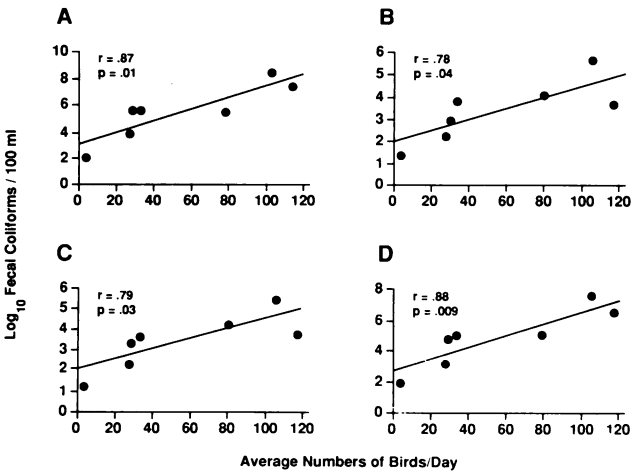

FIG. 1. Correlations between the daily geometric average of the logarithms of FC concentrations and the number of birds on the beach calculated hourly. Depths of water were 0.3 m (A), 0.7 m (B), and 1.2 m (C); panel D shows values for all depths combined.

birds in the study area in mid-July. Immature birds are known to be more frequently colonized, and perhaps more heavily infected, than adults by *Salmonella* spp. (3).

High concentrations of *Aeromonas* spp. were measured (Table 1). The infecting dose for these bacteria is unknown (1), but they have been related to wound infections in swimmers (12, 17) and possibly to human intestinal infections (15). Some *Aeromonas* spp. are also pathogens for other vertebrates. For example, *Aeromonas hydrophila* is the etiological agent of red-sore disease in fish (13).

With FC as indicators, the second study enabled us to measure the extent of microbiological contamination caused by gulls on a public beach. The selected water body was observed throughout the summer, and the water quality remained excellent. Once food was spread on the sand, the number of gulls increased rapidly, as did the concentration of FC in the water. Study of the correlation between the number of gulls and FC indicates that these variables were closely related (Fig. 1). The increase in the number of FC was greatest near the shore (0.3 m) but was also considerable at 0.7 and 1.2 m. After only 2 days and in the presence of 30 birds, the Canadian recommendation for the cleanliness of recreational water (200 FC per 100 ml) (26) had already been exceeded. It is also quite probable that the American standard of fewer than 126 *E. coli* organisms (27) would have

TABLE 2. Variations in the number of gulls on the beach and the concentrations of FC at different depths

Date (September 1991)	No. of gulls[a]	0.3 m		0.7 m		1.2 m		All depths	
		No. of samplings	FC concn[b]	No. of samplings	FC concn	No. of samplings	FC concn	No. of samplings	FC concn
3	3.7	6	8.0	6	3.1	6	2.5	18	6.5
4	27.1	12	48.6	12	8.7	12	9.2	36	24.2
5	32.2	10	263.6	10	45.6	10	33.5	30	143.0
6	29.2	4	273.6	4	17.0	4	27.9	12	121.0
8	78.2	4	247.7	4	55.9	4	67.4	12	162.1
9	114.0	4	1,778.3	4	37.7	4	39.6	12	630.7
10	103.0	6	5,077.3	6	300.6	6	239.3	18	1,987.3

[a] Arithmetic mean of the number of gulls calculated hourly.
[b] Geometric mean of the number of FC per 100 ml of water.

been exceeded, since over 99% of the bacteria in the droppings were *E. coli*.

Using the ratios of *Salmonella* spp. to FC and *Aeromonas* spp. to FC measured in mid-July (Table 1) and FC concentrations determined on 10 September (Table 2), we estimated the concentrations of both bacteria in the water. Using these estimates, we calculated that 4.6 *Salmonella* organisms per 100 ml of water could have been present. Since a swimmer usually ingests between 10 and 100 ml (14) of water, the total number of ingested bacteria would be less than three. Under the same assumptions, the number of *Aeromonas* organisms per 100 ml of water can be estimated at 4,571. Abraded skin could thus be exposed to fairly large concentrations of *Aeromonas* organisms, a genus responsible for infections in humans (1, 12, 15, 17) and animals (13).

The number of gulls on beaches in eastern North America is increasing rapidly; they adapt well to the presence of humans. The widespread tendency of swimmers to feed the gulls causes them to flock in large numbers around natural bodies of water. This can contribute to the microbiological contamination of recreational water. While additional efforts must be made to better document their potential to transmit infection to humans, common sense tells us that we should limit the sources of food in the areas surrounding beaches. Clean beaches, closed garbage bins, and an official ban against feeding gulls are simple means that should enable us to protect ourselves against potential microbiological problems.

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