APPLIED AND ENVIRONMENTAL MICROBIOLOGY, Dec. 1999, p. 5628–5630 Vol. 65, No. 12
0099-2240/99/$04.00+0

Seasonal Enumeration of Fecal Coliform Bacteria from the Feces of Ring-Billed Gulls (*Larus delawarensis*) and Canada Geese (*Branta canadensis*)

K. A. ALDERISIO* AND N. DELUCA

New York City Department of Environmental Protection, Bureau of Water Supply, Quality, and Protection, Division of Water Quality Control, Valhalla, New York 10595

Received 27 April 1999/Accepted 1 October 1999

Water suppliers have often implicated roosting birds for fecal contamination of their surface waters. Geese and gulls have been the primary targets of this blame although literature documenting the fecal coliform content of these birds is quite limited. To determine the actual fecal coliform concentrations of these birds, fecal samples from 249 ring-billed gulls and 236 Canada geese in Westchester County, N.Y., were analyzed over a 2-year period. Results indicate that gull feces contain a greater average concentration of fecal coliform bacteria per gram (3.68×10^8) than do goose feces (1.53×10^4); however, average fecal sample weights of the geese were more than 15 times higher than those of the gulls.

The enumeration of fecal coliform bacteria (FC) has been widely used as an indicator of fecal pollution in drinking water supplies and is relatively quick and inexpensive to monitor (1). The New York City Department of Environmental Protection (NYC DEP) monitors its water supply for FC in many streams, lakes, and reservoirs throughout the watershed. Often in the past, FC concentrations in the Kensico Reservoir in Westchester County, N.Y., became elevated in the autumn and winter periods, coincident with the increased roosting of ring-billed gulls (*Larus delawarensis*) and Canada geese (*Branta canadensis*) (9). It appeared that the birds were adversely affecting the water quality, considering the numbers of birds, location of overnight roosting, and length of stay; however, the quantitative impact could not be determined since the potential FC loading of these birds was not known. The promulgation of the Surface Water Treatment Rule in 1991 required NYC DEP to comply with FC concentration regulations, and as a result, a study of the relationship between waterfowl presence and fecal coliform concentrations in the reservoir was implemented. Bird counts were performed in different areas of the reservoir, and results indicated that sample sites associated with large numbers of roosting waterfowl showed a significant correlation with elevated fecal coliform levels ($r = 0.50, P = 0.01$), whereas samples from sites with no waterfowl present often contained counts of <1 FC/100 ml (9). In 1992, a formalized and benign waterfowl mitigation program was implemented and the seasonal FC elevation at the Kensico Reservoir attributable to birds was largely eliminated.

Some investigators have determined the FC concentration of gull feces; however, it was done in other countries or in captivity or collection was short-term (5, 7). Others have associated the FC impact of waterfowl with the degradation of water supplies but have not directly enumerated levels of FC in bird feces (2, 3, 6, 10). This study was designed to document the possible impact of the bird feces on the water quality of the Kensico Reservoir by determining the FC loading potential of the birds.

* Corresponding author. Mailing address: New York City Department of Environmental Protection, 465 Columbus Ave., Valhalla, NY 10595. Phone: (914) 773-4423. Fax: (914) 773-0365. E-mail: kalderi@valgis.dep.nyc.ny.us.

Sample collection. Known grazing areas for the gulls and geese in Westchester County, N.Y. were visited on a regular basis for sample collection. Droppings were collected in situ immediately after defecation by the birds was observed. Feces were collected with sterile 1-ml tuberculin syringes and forceps and placed into sterile, preweighed 50-ml centrifuge tubes with screw caps. Caution was used so that any surrounding material from the ground or grass area of defecation was not gathered. When notable interference was likely, the sample was passed over and not collected. Tubes were labeled, placed in a cooler with ice packs, and returned to the laboratory for processing within 4 h of the time of collection. Physical descriptions of the feces were also noted (e.g., solid, liquid, color). Samples were collected from 249 ring-billed gulls and 236 Canada geese over the course of 2 years, from September 1995 to September 1997.

Sample analysis. All 485 fecal samples were analyzed independently. Fecal samples were analyzed for overall average concentration and weight, as well as potential seasonal variation for both bird species. Tubes were weighed upon arrival to the laboratory, and the net weights of the samples were determined. To be consistent, the weight of each fecal sample was multiplied by nine to determine the amount of sterile buffered water to be added to each tube to yield a 10^1 dilution. Ten-fold serial dilutions were performed, up to 10^7. Some of the goose samples were not analyzed in their entirety for FC concentration, since portions of the feces occasionally had to be removed to include the buffer. Centrifuge tubes were shaken vigorously and then vortexed for 2 min, and aliquots of 10-fold serial dilutions were pour plated with mFC agar (Difco) onto 15- by 100-mm petri dishes (1). Samples were inverted and incubated in a water bath at 44.5°C for 24 ± 2 h (1).

Incubated plates were observed for the optimum number of CFU, between 30 and 300 colonies per plate (1), and blue colonies were counted from the appropriate dilution with the aid of a Quebec colony counter. Final results were calculated as $w/\mathrm{CFU}(d) = 1/x$, where w is the weight of the fecal sample, CFU is the number of colonies counted, d is the dilution factor, and x is the number of fecal coliforms per gram (wet weight) of feces.

Quality control consisted of routine sterility procedures recommended by Standard Methods for microbiological analyses (1). Duplicates were performed on 58 separate samples that

TABLE 1. Average seasonal weights of fecal samples from gulls and geese[a]

Source of feces	Season	No. of droppings	Avg wet wt (g) (overall avg)[b]
Ring-billed gull	Autumn	54	0.54
	Winter	62	0.42
	Spring	69	0.50
	Summer	64	0.47 (0.48)
Canada goose	Autumn[c]	29	8.23
	Winter[c]	23	5.85
	Spring	54	9.33
	Summer	65	9.98 (8.35)

[a] Fecal samples were collected in Westchester County, N.Y.
[b] Weights of samples collected from 1995 to 1997 were averaged by season.
[c] Goose fecal weights of samples collected during autumn of 1995 and winter of 1996 were not determined.

were collected at times spread out over the duration of the study. No data were rejected based on paired data, although one point failed the rule of Hugh Error based on the log difference between the duplicates. The average log difference was 0.1, which is the relative precision of this technique. Criteria for counting FC followed those of the manufacturer (Difco) and consisted of counting all blue colonies, since over 93% of the blue colonies that develop on mFC medium at the elevated temperature of 44.5 ± 0.2°C are reported to be FC (4). Over 250 blue colonies were verified by using blood agar and MacConkey agar, followed by biochemical identifications (API 20E; bioMerieux Vitek).

The data show that the average fecal sample weights were relatively consistent within each bird type over the 2 years studied, with the exception of the winter of 1997, when the average weight of goose samples was 30% lower than the average from all seasons (Table 1). The winter of 1997 was extremely mild and may have somehow influenced the average fecal weight for that season. Fecal sample weights collected from 171 geese ranged from 0.44 to 25.4 g, with a mean of 8.35 g per goose fecal sample. Individual samples collected from 249 gulls ranged from 0.01 g to an unusually high 2.49 g, with a mean of 0.48 g per gull fecal sample. There were no significant differences in the seasonal averages for the gull fecal sample weights, which ranged from 0.42 to 0.54 g. Weights documented in this study should be considered conservative since some goose and gull fecal samples were not collected in their entirety.

Concentration data indicate that the ring-billed gull feces contain a greater concentration of FC/gram than those of the Canada geese. Over the course of the 2 years, the 249 gull samples averaged 3.68×10^8 FC/g of feces while the 236 goose samples averaged 1.53×10^4 FC/g (Table 2). Average FC concentrations of the gull feces for the eight consecutive seasons studied ranged from 5.84×10^7 to 1.52×10^9 FC/g of feces. The seasonal averages were all within the same order of magnitude, suggesting a fairly stable FC concentration in the gull feces. Conversely, the goose fecal results were more variable. The FC concentrations for the eight seasons of goose samples varied from an average of 4.50×10^3 to 2.42×10^7 FC/g (wet weight) of feces, with seasonal averages ranging from 5.15×10^4 to 1.21×10^7 FC/g (wet weight) of feces, demonstrating less stability in their concentrations than the gull samples. The difference in variability may be explained by the different eating habits of these birds, the goose being more of a grazer than an omnivore. The lowest average goose FC concentration occurred during the winter of 1997, corresponding with the season with the lowest average goose fecal weight.

TABLE 2. Seasonal variations of concentrations of FC in gull and goose feces over 2 years[a]

Source of feces	Time of sampling		No. of droppings[b]	Avg FC concn (CFU/g)[c]
	Season	Yr		
Ring-billed gull	Autumn	1995	29	6.86×10^8
		1996	25	5.84×10^7
	Winter	1996	33	1.90×10^8
		1997	29	1.52×10^9
	Spring	1996	39	1.12×10^8
		1997	30	2.66×10^8
	Summer	1996	39	1.04×10^8
		1997	25	1.42×10^8
Canada goose	Autumn	1995	25	1.53×10^4
		1996	29	8.76×10^4
	Winter	1996	40	2.42×10^7
		1997	23	4.50×10^3
	Spring	1996	21	1.70×10^5
		1997	33	1.75×10^4
	Summer	1996	40	3.00×10^5
		1997	25	6.00×10^6

[a] Fecal samples were collected in Westchester County, N.Y.
[b] There was a total of 249 ring-billed gull droppings and 236 Canada goose droppings.
[c] Overall FC concentrations were 3.68×10^8 CFU/g for ring-billed gull droppings and 1.53×10^4 CFU/g for Canada goose droppings.

In all, the data indicate that the feces from these birds, especially the gulls, contain what can be considered significant numbers of FC per gram. Considering the average weights and FC concentrations of the gull and goose feces examined, they can potentially contribute approximately 1.77×10^8 and 1.28×10^5 FC per fecal deposit to the surface water, respectively. The potential FC impact of these birds is relative to the numbers and types of birds, as well as the duration and time of day that the birds roost on the surface water and their defecation rates. These investigators additionally collected several old, sun-dried fecal samples from docks adjacent to the reservoir and found significant numbers of viable FC bacteria. Samples were analyzed in the same fashion as the fresh feces except that additional buffer was used to facilitate pipetting of the sample. The dried "cakey" feces from five geese yielded a range of FC concentration, from 8.2×10^2 to 3.0×10^5/g. This indicates that runoff from bird feces may also impact water supplies, even if the birds do not roost overnight on the water. Most significantly, it appears that hundreds or thousands of birds roosting on the surface water, especially near intakes to aqueducts, would have an adverse effect on the microbiological quality of the water. This point is further proven in that counts of FC in the Kensico Reservoir decreased significantly once the NYC DEP Waterfowl Mitigation Program was implemented (8).

We gratefully acknowledge the work of Michael Usai, Bryce McCann, and Christopher Nadareski for their persistent and patient efforts in collecting fecal samples in all types of weather.

REFERENCES

1. **American Public Health Association.** 1995. Standard methods for the examination of water and wastewater, 19th ed. American Public Health Association, Washington, D.C.
2. **Bedard, J., and G. Gauthier.** 1986. Assessment of fecal output in geese. J. Appl. Ecol. **23:**77–90.
3. **Benton, C., F. Khan, P. Monaghan, W. N. Richards, and C. B. Sheddens.**

1983. The contamination of a major water supply by Gull (*Larus sp.*). Water Res. **17:**789–798.
4. **Geldreich, E. E., H. F. Clark, C. B. Huff, and L. C. Best.** 1965. Fecal coliform organism medium for the membrane filter technique. J. Am. Water Works Assoc. **57:**208–214.
5. **Gould, D. J., and M. R. Fletcher.** 1978. Gull droppings and their effects on water quality. Water Res. **12:**655–672.
6. **Jones, F., P. Smith, and D. C. Watson.** 1978. Pollution of a water supply catchment by breeding gulls and the potential environmental health implications. J. Inst. Water Engineers Scientists **32:**469–482.
7. **Lévesque, B., P. Brousseau, P. Simard, E. Dewailly, M. Meisels, D. Ramsay, and J. Joly.** 1993. Impact of the ring-billed gull (*Larus delawarensis*) on the microbiological quality of recreational water. Appl. Environ. Microbiol. **59:** 1228–1230.
8. **New York City Department of Environmental Protection.** 1998. Kensico watershed study, annual research report. April 1997–March 1998. New York City Department of Environmental Protection, Valhalla, N.Y.
9. **New York City Department of Environmental Protection (DEP).** 1993. Kensico watershed study, 1991–1993. New York City Department of Environmental Protection, Valhalla, N.Y.
10. **Standridge, J. H., J. J. Delfino, L. B. Kleppe, and R. Butler.** 1979. Effect of waterfowl (*Anas platyrhynchos*) on indicator bacteria populations in a recreational lake in Madison, Wisconsin. Appl. Environ. Microbiol. **38:**547–550.