Chapter 5:

DISEASE MORTALITY EVENTS INVOLVING ROSS'S GEESE

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Based on disease outbreaks reported to the U.S. Geological Survey (USGS) National Wildlife Health Center since 1968, the principal disease affecting Ross's geese is avian cholera (Tables 1 and 2). Other causes of mortality include losses during severe storms, botulism Type C, necrotic enteritis, soybean impaction, and two pesticide poisoning events. A number of avian cholera mortality events have coincided with lead poisoning mortality. Mortality events involving light geese (Ross's and snow geese) in the Central Flyway showed a gradual increase in the frequency and total severity of losses occurring since the 1960s (Table 1). All of the mortality events in the Central Flyway that involved Ross's geese also included snow geese. Ross's geese were typically a small proportion of the light geese that died during these mortality events. In the Pacific Flyway, the frequency of mortality events involving Ross's geese was similar during the 1980s and 1990s, but the severity of losses increased 2-3 times during the later period (Table 2). Most of these events included both Ross's and snow geese; however, a few events involved Ross's geese without snow geese. Many additional mortality events that occurred in the Central and Pacific Flyways involved snow geese, but Ross's geese were not reported during these events (Table 3 and 4). Causes of the mortality events that involved snow, but not Ross's geese were similar to those reported for both species. Avian cholera was the primary cause of mortality, followed by botulism, lead poisoning, drowning, and several toxic events. Avian cholera outbreaks have also been reported during spring migration from western Canada, especially in the late 1970s and early 1980s (Wobeser et al. 1979, 1982) and these outbreaks seemed to be confined almost entirely to snow and Ross's geese (Wobeser 1992). In summary, it appears that most of the general disease and mortality factors that affect snow geese also affect Ross's geese. In general, it is not known whether the frequency of events or magnitude of losses reflects the relative abundance of Ross's and snow geese and/or changes in light goose abundance over time. However, an increase in snow goose populations since the 1980s has corresponded with an increase in the magnitude of avian cholera mortality occurring in Nebraska's Rainwater Basin (M. D. Samuel, USGS, and G. Mack, U.S. Fish and Wildlife Service, unpublished data).

Previous studies have provided limited information about the potential impacts and role of Ross's geese in avian cholera outbreaks. Rosen (1972) compared the winter abundance of several waterfowl species in California during 1970/71 to losses from avian cholera. Although more snow geese died than Ross's geese the percentage of mortality was 7.3% of the wintering Ross's goose population and 1.5% of the snow goose population. Rosen (1972) concluded that avian cholera mortality in the winter of 1970/71

may have impacted Ross's geese in California. McLandress (1983) indicated that >90% of the disease mortality in Ross's and snow geese during 1975-77 in California was caused by avian cholera. The conclusion that avian cholera is the primary cause of disease mortality in light geese is also supported by the data from mortality events throughout the Central and Pacific Flyways. Although the patterns of vulnerability may vary by age and sex classes or degree of disease severity, McLandress (1983) concluded that snow and Ross's geese had similar susceptibility to avian cholera.

Although avian cholera kills thousands of waterfowl annually in North American wetlands, the reservoir for *Pasteurella multocida*, the bacterium that causes this highly infectious disease, has been uncertain (Botzler 1991). Two potential reservoirs have been suggested as a source of this bacterium for waterfowl populations: carrier birds and wetland sites. Recent studies have been conducted by the USGS National Wildlife Health Center to evaluate the wetland reservoir hypothesis. One study was conducted during and following avian cholera outbreaks to determine how long *P. multocida* survived in wetlands and a second study was conducted during the subsequent fall to determine whether *P. multocida* persisted in wetlands until migratory birds arrived. Results from these studies indicated that *P. multocida* did not survive in wetlands for extended periods once outbreaks had ceased. In addition, the bacterium was not present during the fall in years following outbreaks (M. D. Samuel et al., USGS, unpublished data). These results are contrary to the hypothesis that wetlands are the primary reservoir for this disease.

In contrast to the wetland hypothesis, some investigators have suspected that avian cholera was primarily perpetuated by carrier birds (Wobeser 1992) and that light geese may be the primary source of disease because outbreaks have been associated with their fall and spring migration (Brand 1984; Wobeser et al. 1979, 1982), they suffer outbreaks and chronic mortality every year (Mensik and Samuel 1995), outbreaks that may perpetuate the disease cycle occur on snow goose breeding areas (Samuel et al. 1999a), and the magnitude of mortality in other species has been associated with snow goose mortality (M. D. Samuel, USGS, and G. Mack, U.S. Fish and Wildlife Service, unpublished data). Recent studies on snow geese in the western Arctic found that some snow geese may be carriers of *P. multocida* (Samuel et al. 1997), and about half of the snow geese infected with avian cholera during outbreaks on the breeding grounds survived infection (Samuel et al. 1999b). Samuel et al. (1999b) suspected that these survivors could be carriers of the bacteria and play an important role in transmitting the organism to susceptible birds. Because snow geese are frequently involved in avian cholera outbreaks, associate in dense winter aggregations, and nest in colonies which seem to facilitate continuation of the disease cycle, Samuel et al. (1999b) believed that snow geese may be particularly important in the epizootiology of avian cholera. Unfortunately, there is little corresponding information on the potential role of Ross's geese in the epizootiology of avian cholera and whether these geese may also be important in the disease cycle. Because these two species of light geese have similar behavior patterns, extensively intermingle on migration and wintering areas, and occur in dense aggregations, it seems plausible that they may play similar roles in the epizootiology of avian cholera. However, it would be difficult to separate the potential

role of Ross's geese in this disease without specific research studies to determine if they are carriers of *P. multocida*. Early results from research examining the occurrence and frequency of avian cholera carriers in the Playa Lakes region suggest both snow and Ross's geese can be carriers of P. multocida (M. D. Samuel, USGS, unpublished data). Similar research studies on snow and Ross's geese have been recommended for the Central Valley of California.

In addition to its potential impact on light geese, avian cholera is of particular concern because most species of waterfowl, raptors, and other birds using wetland ecosystems are susceptible (Botzler 1991, Friend 1999). Although the factors that trigger an outbreak are poorly understood, it is commonly believed that weather, stress, and high densities of susceptible birds are important contributors (Botzler 1991, Windingstad et al. 1998). Increased densities of waterbirds, especially gregarious light goose species, probably increase the risk of disease transmission and outbreak events (Wobeser 1992). Once an outbreak starts, wetland contamination from diseased birds is the primary source of infection to susceptible birds of all species, although other routes of transmission such as bird-to-bird contact are likely (Wobeser 1992). Some species of waterfowl, especially light geese, may carry the organism and be more disposed to avian cholera outbreaks, which concurrently or subsequently affect other less susceptible species. In addition, the increased abundance of light geese and the large-scale mixing of these populations may enhance the exchange and spread of avian cholera and other disease agents (Wobeser 1992). Loss of habitat, increased abundance of light geese and other waterfowl, and increased densities of waterbirds are all factors that likely contribute to increasing the risk of avian cholera outbreaks, increasing the risk of infecting other waterbirds using the same wetlands, and increasing the continental distribution of this infectious disease.

Table 1. Summary of mortality events involving Ross's geese in the Central Flyway, 1968-2000.

Dates	Mortality events			Minimum estimated dead[a]			Summary by location and diagnosis		
	Total	Ross's only	Ross's and snow	Total	Ross's	Snow	States/Provinces[b]	n	Diagnosis
1968-79	2	0	2	300	unk.	unk.	NE	1	Storm trauma
				2,724	unk.	unk.	NE	1	Avian cholera and lead poisoning
1980-89	8	0	8	12,691	69	6,750	NM (3), NE (2), Alberta, CAN	6	Avian cholera (In one event birds were also diagnosed with lead poisoning and storm trauma)
				300	30	175	NM	1	Botulism type C and avian cholera
				13	unk.	unk.	NM	1	Diazinon toxicosis
1990-2000	28	0	28	75,590	2281	55,452	NE (14), TX (3), SD (2), CO, KS, Saskatchewan CAN, Chihuahua MEX (2)	24	Avian cholera or suspect avian cholera (In some events birds were also diagnosed with lead poisoning, gout, or suspect aflatoxicosis).
				743	2	89	ND	2	Necrotic enteritis
				10,000	unk.	1,021	NE	1	Storm trauma
				137	unk.	unk.	OK	1	Soybean impaction

[a] Totals include either direct number of carcasses collected or estimated mortality.
[b] Parentheses indicted the number of events in each state.
Unk. Individual estimates of mortality not available for all species.

Table 2. Summary of mortality events involving Ross's geese in the Pacific Flyway, 1970-2000.

Dates	Mortality events			Minimum estimated dead[a]			Summary by location and diagnosis		
	Total Events	Ross's only	Ross's and snow	Total	Ross's	Snow	States/Provinces[b]	n	Diagnosis
1970-79	3	1	2	2,624	218	1,250	CA (3)	3	Avian cholera
1980-89	58	3	55	26,625	1,257	4,320	CA (29)	29	Avian cholera
				20,124	1,472	6,146	CA (24), OR	25	Avian cholera (In all events, some birds were also diagnosed with lead poisoning, botulism type C or trauma).
				17,356	37	154	CA (3)	3	Botulism type C (In some events birds were also diagnosed with avian cholera, and/or lead poisoning).
				6	1	5	CA	1	Dimethoate toxicosis
1990-2000	50	2	48	79,551	2,663	4,431	CA (33), MT, NV	35	Avian cholera or suspect avian cholera
				33,679	1,986	4,274	CA (11)	11	Avian cholera (In all events, some birds were also diagnosed with lead poisoning, botulism type C, trauma, aspergillosis and/or tracheal obstruction).
				5,304	5	20	CA (2)	2	Botulism type C
				1,500	82	205	CA	1	Storm trauma
				20	3	unk.	CA	1	Open

[a] Totals include either direct number of carcasses collected or estimated mortality.
[b] Parentheses indicted the number of events in each state.
Unk. Individual estimates of mortality not available for all species.

Table 3. Summary of mortality events involving snow geese, but not Ross's geese in the Central Flyway, 1970-2000.

Dates	Total mortality events	Minimum estimated dead[a]		Summary by location and diagnosis		
		Total	Snow	State/Province[b]	n	Diagnosis
1970-79	11	47,828	2,847	NE (5), TX (3), MT, SD	10	Avian cholera (In some events birds were also diagnosed with lead poisoning or suspect aflatoxicosis).
		7,500	unk.	TX	1	Aflatoxicosis
1980-89	68	176,819	2,962	NE (19), TX (7), SD (3), CO (2), NM (2), KS, WY	35	Avian cholera or suspect avian cholera (In all events, some birds were also diagnosed with lead poisoning, and/or aspergillosis, gunshot trauma).
		860	432	TX (3), NE (3), SD	7	Lead poisoning (In some events birds were also diagnosed with avian cholera or gunshot trauma).
		575	18	ND (2), OK (2), TX, NE	6	Toxicosis pesticide suspect (In one event birds were also diagnosed with visceral gout).
		4,097	3,095	ND (2), SD (2), Manitoba CAN	5	Necrotic enteritis or suspect necrotic enteritis (In one event birds were also diagnosed with sodium toxicosis and aspergillosis).
		9,050	72	TX (4)	4	Mycotoxicosis or aflatoxicosis. (In some events birds were also diagnosed with lead poisoning, avian cholera, and/or gunshot trauma).
		29	6	IA, ND, TX	3	Open

		180	30	ND (2)	2	Sodium toxicosis or suspect sodium toxicosis
		500	unk.	CO	1	Botulism type C
		1,600	unk.	TX	1	Parathion toxicosis
		97	unk.	OK	1	Fluorine toxicosis
		400	unk.	SD	1	Nitrate toxicosis
		100	unk.	TX	1	Storm trauma and gunshot
		52	2	NM	1	Salmonellosis suspect
1990-2000	51	34,053	21,848	TX (11), NE (6), NM (4), SD (3), CAN (2), ND, CO	28	Avian cholera or suspect avian cholera (In one event birds were also diagnosed with lead poisoning, necrotic enteritis, gunshot trauma).
		384	32	TX (4), KS, NM	6	Open
		1,925	1,756	ND (4), SD	5	Necrotic enteritis or enteritis
		287	267	TX (2)	2	Lead poisoning
		1,952	unk.	TX (2)	2	Aflatoxicosis (In one event birds were also diagnosed with avian cholera).
		144	81	KS, NE	2	Aspergillosis (In one event birds were also diagnosed with trauma).
		45	16	TX	1	Septicemia and open
		2,500	unk.	SD	1	Sodium toxicosis
		45	7	OK	1	Soybean impaction
		134	14	NE	1	Storm trauma
		34	34	TX	1	Hepatitis
		3,061	9	ND	1	Botulism type C

[a] Totals include either direct number of carcasses collected or estimated mortality.
[b] Parentheses indicted the number of events in each state.
Unk. Individual estimates of mortality not available for all species.

Table 3. Continued.

Table 4. Summary of mortality events involving snow geese, but not Ross's geese in Pacific Flyway, 1970-2000.

Dates	Total mortality events	Minimum estimated dead[a]		Summary by location and diagnosis		
		Total	Snow	State/Province[b]	n	Diagnosis
1970-79	9	14,310	10,330	CA (6), CAN (2)	8	Avian cholera (In some events birds were also diagnosed with aspergillosis, lead poisoning and/ or gunshot trauma).
		1,244	58	CA	1	Botulism, avian cholera and lead poisoning
1980-89	37	40,538	35,380	CA (19), OR (2), ID	22	Avian cholera (In all events, some birds were also diagnosed with lead poisoning, botulism type C or trauma).
		7,080	14	CA (6)	6	Botulism type C (In some events birds were also diagnosed with lead poisoning).
		713	102	CA (5)	5	Lead poisoning
		40	unk.	CA	1	Zinc phosphide toxicosis
		57	unk.	CA (2)	2	Carbofuran toxicosis
		369	10	CA	1	Open
1990-2000	19	37,411	10,585	CA (13), Saskatchewan CAN (2), ID	16	Avian cholera (In one event birds were also diagnosed with lead poisoning).
		10	10	CA	1	Trauma
		60	unk.	CA	1	Lead poisoning
		200	unk.	AK	1	Drowning suspect

[a] Totals include either direct number of carcasses collected or estimated mortality.
[b] Parentheses indicted the number of events in each state.
Unk. Individual estimates of mortality not available for all species.

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