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Human Salmonellosis Associated with Exotic Pets

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During the period from 1994 to 1996, an increase in the number of laboratory-confirmed cases of human salmonellosis associated with exposure to exotic pets including iguanas, pet turtles, sugar gliders, and hedgehogs was observed in Canada. Pet turtle-associated salmonellosis was recognized as a serious public health problem in the 1960s and 1970s, and in February 1975 legislation banning the importation of turtles into Canada was enacted by Agriculture Canada. Reptile-associated salmonellosis is once again being recognized as a resurgent disease. From 1993 to 1995, there were more than 20,000 laboratory-confirmed human cases of salmonellosis in Canada. The major source of *Salmonella* infection is food; however, an estimated 3 to 5% of all cases of salmonellosis in humans are associated with exposure to exotic pets. Among the isolates from these patients with salmonellosis, a variety of *Salmonella* serotypes were also associated with exotic pets and included the following: *S. java*, *S. stanley*, *S. poona*, *S. jangwani*, *S. tilene*, *S. litchfield*, *S. manhattan*, *S. pomona*, *S. miami*, *S. rubislaw*, *S. marina* subsp. IV, and *S. wassenaar* subsp. IV.

Salmonellosis is one of the most important public health disease problems, affecting more people and animals than any other single disease (16). In Canada, there were a total of 8,057 laboratory-confirmed cases of salmonellosis in 1993, 7,324 cases in 1994, and 7,138 cases in 1995 (10). The incidence of human cases of salmonellosis is thought to be many times greater than the number of reported and confirmed cases, even in countries with well-organized surveillance activities (16). In fact, it is estimated that each year in Canada alone, salmonellosis affects 2.4% of the total population, an equivalent of 627,200 cases of illness (15). There can be little disagreement that with the impact of cost on medical care and the loss of productivity, salmonellosis is a very real and underestimated problem (16).

Salmonella infection is recognized as a zoonosis, and the overall epidemiological pattern of *Salmonella* infection is related predominantly to animal reservoirs (16, 18). The native habitat of members of the genus *Salmonella* is the intestinal tract of warm-blooded and many cold-blooded vertebrates, from which the organisms are easily spread to other environments where they may readily survive and multiply (16).

In the human host, after an incubation period of 6 to 48 h (usually 12 to 24 h), *Salmonella* produces symptoms of headache, malaise, nausea, fever, vomiting, abdominal pain, and diarrhea (with or without blood) (2, 16). Salmonellae are also potentially capable of invading the intestinal mucosa, entering the bloodstream, and causing septicemia and death.

Salmonellosis associated with the importation of exotic pets is once again being recognized as a rapidly emerging disease in Canada. The genus *Salmonella* comprises more than 2,400 serotypes (14). Of these, an increasing number of uncommon but characteristic serotypes associated with exotic pets are being observed in association with cases of salmonellosis in humans.

To gain a better scientific understanding of this, *Salmonella* serotyping has been used as an epidemiological marker to study the incidence of *Salmonella* infection in exotic pets and the associated transmission to humans.

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MATERIALS AND METHODS

The *Salmonella* cultures were actively submitted for identification, serotyping, and confirmation by the provincial public health laboratories, federal laboratories, and veterinary laboratories across Canada (10). Standardized forms requesting epidemiological information were supplied to the laboratories submitting the cultures, and the completed forms accompanied the cultures of isolates being sent. Surveillance data on human and nonhuman isolates were also passively acquired. In epidemiological studies related to human infection, the same *Salmonella* serotypes observed in humans were also identified in exotic pets.

Serotyping. *Salmonella* cultures were investigated to determine somatic (O) and flagellar (H) antigens (8, 9, 14). All serotypes were identified by the Kaufmann-White *Salmonella* serotyping scheme published by Institut Pasteur (14).

RESULTS

During the period from 1991 to 1996, a variety of *Salmonella* serotypes involving exotic pets were observed in Canada (Table 1). Among these, the most frequently encountered sources were turtles, iguanas, lizards, and hedgehogs. Approximately 198 laboratory-confirmed cases of *Salmonella* infection in exotic pets were detected, and these were caused by 31 of the major *Salmonella* serotypes associated with this zoonosis (Table 1). Of these, 108 (55%) *Salmonella* organisms from turtles were distributed among 15 serotypes, 65 (33%) organisms from iguanas were distributed among 17 serotypes, 9 (5%) organisms from lizards were distributed among 4 serotypes, and 5 (3%) organisms from hedgehogs were distributed between 2 serotypes (Table 1). The majority of exotic pets (89%) in which *Salmonella* serotypes were identified were found in three provinces in Canada (Table 1): Ontario (n = 82; 41%), Saskatchewan (n = 55; 28%), and Alberta (n = 40; 20%).

The major *Salmonella* serotypes observed included *S. pomona* (turtles; n = 21), *S. java* (turtles; n = 20), *S. stanley* (turtles; n = 18), *S. poona* (iguanas [n = 12] and turtles [n = 3]), *S. muenchen* (turtles [n = 9] and iguanas [n = 4]), *S. marina* (iguanas; n = 10), *S. newport* (turtles [n = 8] and iguanas [n = 2]), *S. chameleon* (iguanas; n = 9), and *S. tilene* (hedgehog [n = 4] and sugar glider [n = 2]) (Table 1).

During the same period, the major uncommon *Salmonella*

TABLE 1. Distribution of major *Salmonella* serotypes associated with exotic pets from 1991 to 1996

Salmonella serotype[b]	Source	No. of organisms isolated[a]										
		BC	ALTA	SASK	MAN	ON	QUE	NB	NS	PEI	NFLD	Total
S. abaetetuba 11:k:1,5	Iguana	2										2
S. anatum 3,10:e,h:1,6	Iguana			2								2
S. cerro 6,14,18:z4,z23:−	Iguana					1						1
S. chameleon subsp. IV 16:z4,z32:−	Iguana		6	1					2			9
S. ealing 35:g,m,s:−	Turtle water			3		2						5
S. ealing 35:g,m,s:−	Turtle					1						1
S. ealing 35:g,m,s:−	Frog		1									1
S. ealing 35:g,m,s:−	Lizard		1									1
S. florida 6,14,25:d:1,7	Iguana					1						1
S. fluntern 18:b:1,5	Iguana							1				1
S. houten subsp. IV 43:z4,z23:−	Iguana		2									2
S. houten subsp. IV 43:z4,z23:−	Chameleon		1									1
S. java 4,5,12:b:1,2	Turtle		1									1
S. java 4,5,12:b:1,2	Turtle water			6		14						20
S. javiana 1,9,12:l,z28:1,5	Turtle water			1								1
S. javiana 1,9,12:l,z28:1,5	Iguana		2									2
S. kralendyk 6,7:z4,z24:− ssp. IV	Iguana			1		1						2
S. litchfield 6,8:l,v:1,2	Turtle and turtle water					2						2
S. lome 9,12:r:z6	Snake		2	1								3
S. manhattan 6,8:d:1,5	Iguana		3									3
S. marina subsp. IV 48:g,z51:−	Iguana		2	4	1	2			1			10
S. jangwani 17:a:1,5	Turtle						1					1
S. miami 9,12:a:1,5	Turtle water					4						4
S. monschaui 35:m,t:−	Turtle water			1		1		1				3
S. muenchen 6,8:d:1,2	Iguana	2							2			4
S. muenchen 6,8:d:1,2	Turtle water		2	7								9
S. muenchen 6,8:d:1,2	Lizard		2									2
S. muenster 3,10:e,h:1,5	Turtle water			3		2						5
S. newport 6,8:e,h:1,2	Iguana		1			1						2
S. newport 6,8:e,h:1,2	Turtle water			1		6						7
S. newport 6,8:e,h:1,2	Turtle		1									1
S. newport 6,8:e,h:1,2	Snake	1				1						2
S. panama 9,12:l,v:1,5	Snake	1										1
S. panama 9,12:l,v:1,5	Lizard		1									1
S. panama 9,12:l,v:1,5	Turtle water					4						4
S. pomona 28:y:1,7	Turtles and turtle water			4		17						21
S. poona 13,22:z:1,6	Iguana		2	7		3						12
S. poona 13,22:z:1,6	Turtle					2					1	3
S. poona 13,22:z:1,6	Lizard		1	3		1		1				6
S. phoenix subsp. II 47:b:1,5	Iguana	1		1								2
S. phoenix subsp. II 47:b:1,5	Turtle water					1						1
S. rubislaw 11:r:e,n,x	Iguana			1								1
S. rubislaw 11:r:e,n,x	Turtle water					1						1
S. stanley 4,5,12:d:1,2	Turtles and turtle water	1		5		12						18
S. tilene 40:e,h:1,2	Sugar glider		2									2
S. tilene 40:e,h:1,2	Hedgehog		3									3
S. typhimurium 4,5,12:i:1,2	Hedgehog			1								1
S. wassenaar subsp. IV 50:g,z51:−	Iguana		1	1								2
S. wassenaar subsp. IV 50:g,z51:−	Lizard							1				1
Salmonella subsp. IV 45:g,z51:−	Iguana	1	3	1		2						7

[a] BC, British Columbia; ALTA, Alberta; SASK, Saskatchewan; MAN, Manitoba; ON, Ontario; QUE, Quebec; NB, New Brunswick; NS, Nova Scotia; PEI, Prince Edward Island; NFLD, Newfoundland.

[b] Many other *S. arizonae* subsp. IIIa and IIIb and *Salmonella* subsp. IV serotypes have been associated with exotic pets.

serotypes that were isolated from humans and that were also observed in exotic pets included *S. java* (453 patients), *S. stanley* (380 patients), *S. poona* (151 patients), *S. litchfield* (58 patients), *S. manhattan* (38 patients), *S. pomona* (30 patients), *S. miami* (25 patients), *S. jangwani* (13 patients), *S. marina* (12 patients), *S. tilene* (9 patients), *S. chameleon* (8 patients), *S. rubislaw* (7 patients), and *S. wassenaar* (7 patients) (Table 2).

A total of at least 37 cases of human salmonellosis with a firmly established epidemiological link to exotic pets were documented in Canada during a 3-year period (1994 to 1996). These included cases of salmonellosis caused by serotypes *S. poona* (1 case in association with a turtle and 1 case in association with an iguana), *S. wassenaar* (6 cases in association with iguanas), *S. tilene* (5 cases in association with sugar gliders and 4 cases in association with hedgehogs), *S. jangwani* (10 cases in association with turtles), *S. montevideo* (1 case in association with an iguana), and *S. marina* (4 cases in association with iguanas) (Table 3). Among these, two family-related outbreaks occurred, one involving three cases of *S. tilene* infection associated with pet sugar gliders and a second outbreak involving five cases of *S. wassenaar* infection associated with a pet iguana (Table 3).

TABLE 2. Uncommon *Salmonella* serotypes associated with humans, 1991 to 1996[a]

Salmonella serotype	No. of organisms[a]										
	BC	ALTA	SASK	MAN	ON	QUE	NB	NS	PEI	NFLD	Total
S. java	86	28	39	9	217	12	50	5	5	2	453
S. stanley	99	60	20	29	138	2	20	4	1	7	380
S. poona	7	11	8	7	113	3				2	151
S. litchfield	10	8	1	8	26		2	3			58
S. manhattan	3	2		12	16		2	2	1		38
S. pomona	2	3	3	11	6	4	1				30
S. miami	4	8		1	12						25
S. jangwani					1	11		1			13
S. marina	3	3		4	2						12
S. tilene		5	1	1	2						9
S. chameleon		6		1	1						8
Salmonella 45:g,z51:−	1			1	4					1	7
S. rubislaw		3			4						7
S. wassenaar			5		1					1	7
S. kralendyk		1									1
S. phoenix	1										1

[a] These uncommon *Salmonella* serotypes and numerous *S. arizonae* subsp. IIIa and IIIb and *Salmonella* subsp. IV serotypes associated with humans have also been observed in exotic pets.
[b] See footnote *a* of Table 1.

DISCUSSION

Salmonellosis associated with exotic pets constitutes a serious public health problem. This is highlighted by observations in Canada in the last 3 years of increases in uncommon *Salmonella* serotypes in association with infections in humans. *Salmonella* serotypes commonly associated with exotic pets, particularly iguanas and turtles, are among the causes of infection in humans and include the serotypes *S. java*, *S. stanley*, *S. poona*, *S. litchfield*, *S. manhattan*, *S. pomona*, *S. miami*, *S. jangwani*, *S. tilene*, and *S. rubislaw*. Also increasingly observed as causes of infections in humans are *S. arizonae* subsp. IIIa and IIIb and *Salmonella* subsp. IV, which are traditionally observed in cold-blooded vertebrates (Table 2).

In 1975 Agriculture Canada enacted legislation banning the importation of turtles into Canada; however, imported embryonated turtle eggs may be a source of continuing human infection in Canada (4, 5, 17). Iguana-associated salmonellosis is directly linked to the importation into the United States of more than 1 million farm-bred baby iguanas as pets from Central and South America since 1993 (1, 3, 17). Of these, many have subsequently been imported into Canada and are replacing turtles as the most popular reptilian pet of choice. In the United States *Salmonella* serotypes with the same epidemiological link to exotic pets have been observed as causes of disease in humans and have been associated with both morbidity and mortality (Table 4) (3, 17). In particular, *S. poona* represents a predominant serotype directly linked in one case to the death of a 3-week-old baby boy and in a second case to infection of a mother and baby resulting in a premature birth and the death of the child (Table 4). *S. poona* has also been isolated from patients with septicemia and from the cerebrospinal fluid of a child. Epidemiological investigations revealed

TABLE 3. Human *Salmonella* infections in Canada associated with exotic pets, 1994 to 1996

Salmonella serotype	No. of cases of infection	Location[a]	Epidemiological link
S. poona	1	NFLD	Associated with pet turtle
S. poona	1	ALTA	3-yr-old boy; associated with pet iguana
S. wassenaar subsp. IV	1	SASK	Associated with pet iguana
S. wassenaar subsp. IV	5	SASK	Five cases in one family; associated with pet iguana
S. tilene	5	ALTA	Three cases in one family; associated with pet sugar glider
S. tilene	1	SASK	4-mo-old baby boy; associated with hedgehog
S. tilene	1	MAN	2-yr-old baby boy; associated with hedgehog
S. tilene	2	ON	Associated with hedgehogs
S. jangwani	1	NS	Child visiting a home with baby turtles
S. jangwani	9	QUE	Associated with turtles
S. montevideo	1	MAN	Renal transplant recipient; associated with pet iguana
S. marina subsp. IV	1	MAN	Blood and urine of 11-yr-old boy; associated with pet iguana
S. marina subsp. IV	2	MAN	Twin baby brothers; associated with iguana in foster home
S. marina subsp. IV	1	ALTA	Baby boy; associated with pet iguana
S. braenderup	1	BC	Associated with pet turtle
S. abaetetuba	2	BC	Family has pet iguanas
S. typhimurium	1	BC	6-yr-old boy; associated with pet hedgehog
S. java	1	BC	Associated with turtle

[a] See footnote *a* of Table 1.

TABLE 4. Human *Salmonella* infections in the United States associated with exotic pets, 1994 to 1995[a]

Salmonella	No. of cases	Location	Epidemiological serotype link[b]
S. poona	1	Indiana	3-wk-old baby boy who died; pet iguana
S. poona	1	Pennsylvania	21-day-old girl; pet iguana
S. poona	2	New York	Mother and baby, premature birth, child died; family had pet iguana
S. poona	1	Not stated	3-mo-old girl; isolated from CSF; pet iguana
S. poona	1	Not stated	2-yr-old girl, stool and blood 5 wk after family purchased pet iguana
S. wassenaar	1	Connecticut	40-yr-old man; pet iguanas
S. rubislaw	1	New Jersey	5 month old girl; iguana at home of babysitter
Salmonella subsp. IIIa 41:z4,z23:−	1	New York	45-yr-old infected with HIV, owned a corn snake
S. kintambo	1	North Carolina	Blood of a 9-day-old boy; pet lizard
S. stanley	1	Ohio	Blood of a 6-wk old boy; pet turtle
S. montevideo	2	Not stated	Two brothers, ages 3 mo and 6 yr
S. panama	1	Not stated	Bloody diarrhea 6 wk after family purchased iguana

[a] Data are from previous reports (2, 3).
[b] CSF, cerebrospinal fluid; HIV, human immunodeficiency virus.

that both families of the affected patients had pet iguanas, and the majority of cases of infection involved babies and young children (3, 17).

Salmonellosis has also been diagnosed in patients who have hedgehogs as pets. The African pygmy hedgehog, an exotic pet, has been associated with a rare type of *Salmonella* causing human illness; the organism has been identified as serotype *S. tilene* (12). In 1994, *S. tilene* was isolated from the diarrheal stool sample of a 10-month old girl in Washington State. The family owned a breeding herd of 80 African pygmy hedgehogs, and a cultured stool sample from one of three hedgehogs yielded *S. tilene*. Significantly, the infant did not have direct contact with the hedgehogs but the hedgehogs were frequently handled by a family member. The infant was the first human documented to be infected with this serotype in the United States (12). In Canada, the first isolation of *S. tilene* from humans (five patients) occurred in 1995 in Alberta, and the infections were found to be associated with imported sugar gliders (an Australian marsupial [flying squirrel]) and African pygmy hedgehogs (Table 3). Breeders throughout Canada are now distributing hedgehogs, which are considered to be small, unique, low-maintenance pets (7). Notably, a migration of laboratory-confirmed cases of *S. tilene* infection in humans has been observed in a pattern consistent with this distribution of hedgehogs: Alberta (one case of infection), Saskatchewan (one case of infection), Manitoba (one case of infection), and Ontario (two cases of infection). Recently (January 1997), a case of *S. tilene* infection involving a 3-year-old child who had had contact with hedgehogs occurred on Prince Edward Island. The recent popularity of pet hedgehogs, particularly those of African origin, may lead to increasing numbers of *Salmonella* infections in the years to come.

An estimated 90% of all reptiles carry and shed *Salmonella* in their feces. For this reason, exotic pets, in particular, turtles and iguanas, represent important reservoirs of *Salmonella* infection. A variety of *Salmonella* serotypes have been identified from these pets, and their occurrence in humans represents a marker for exposure to reptiles (1, 17). In humans, *Salmonella* infections can be fatal, and it has been recommended that persons at high risk of *Salmonella* infection, that is, those with immature or weakened immune systems, including babies, children younger than 5 years of age, pregnant women, elderly people, and people with AIDS, should avoid contact with reptiles (17). Additional recommendations for reducing the risk of transmission of *Salmonella* to humans from exotic pets include the following. (i) Handlers (breeders, distributors, owners, etc.) of exotic pets should wash their hands thoroughly immediately after direct or indirect contact. Secondary transmission of *Salmonella* to those who have not had direct contact with exotic pets can occur by contact with handlers who have not thoroughly washed their hands. (ii) Aquariums and housing cages for exotic pets should not be cleaned in sinks or be located in vicinities where food may be prepared for human consumption. (iii) Exotic pets should be confined to aquariums or housing cages and should not be permitted free access to areas occupied by families and children (kitchens, recreation rooms, day-care centers, classrooms, etc.). (iv) Exotic pets should not be fed raw meats, including raw ground beef. This could create the potential for the spread of other dangerous enteric pathogens such as *Escherichia coli* O157:H7. (v) Veterinarians and pet store owners should provide information to potential purchasers and owners about the increased risk of acquiring salmonellosis from exotic pets (17). Reducing the potential risk of contracting *Salmonella* infections from exotic pets is a measure of responsible ownership, public awareness, and education.

Human salmonellosis associated with exotic pets is now being recognized as a reemerging disease, and of growing concern is the increasing use of antibiotics by breeders and wholesalers in the prophylactic treatment of iguanas to prevent disease (3). This practice can contribute to the development of antibiotic-resistant *Salmonella* strains, which in humans can cause life-threatening infections that no longer respond to antibiotic therapy (3, 6). In 1992, an expert committee of the Institute of Medicine issued a report, *Emerging Infections: Microbial Threats to Health in the United States* (11), that defined emerging infections broadly as "new, reemerging or drug-resistant infections whose incidence in humans has increased within the past two decades or whose incidence threatens to increase in the near future" (11). This is particularly relevant to salmonellosis associated with exotic pets, which has become resurgent and which has the potential to result in the development of antibiotic-resistant strains.

Surveillance activities at the National Laboratory for Enteric Pathogens, Health Canada, Ottawa, Ontario, use *Salmonella* serotyping as an epidemiological marker to study the incidence and distribution of and the trends and risk factors associated with *Salmonella* infections in humans and the transmission of

salmonellae from food, water, and nonhuman sources (10). This study of exotic pets associated with human salmonellosis provides valuable scientific information based on hazard identification. As a risk assessment and management tool this can be used to increase public awareness through education and assist in the development of effective intervention strategies for prevention and control measures.

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