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Ontario

Scales, Tails and *Salmonella*: A Comparative Analysis of Human and Reptile Isolates

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Public Health Ontario Rounds

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Learning Objectives

- List common *Salmonella* serotypes associated with reptiles.
- Describe the *Salmonella* transmission risks associated with reptile ownership.
- Identify the association between *Salmonella*, reptiles and feeder prey to support outbreak investigations.
- Identify practices that can reduce the risk of infection from reptile contact.

Zoonotic Infections[1]

"A zoonosis is any disease or infection that is naturally transmissible from vertebrate animals to humans. There are over 200 known types of zoonoses."

World Health Organization

- Zoonotic pathogens may be bacterial, viral or parasitic
- People may be exposed through direct or indirect contact with animals via bites, scratches, ingestion or inhalation
- Young children, older adults, pregnant women and individuals with weakened immune systems may be at increased risk of infection and severe illness

Salmonella [2,3]

- Second most common bacterial cause of reportable enteric illness in Ontario
- Over 2,000 serotypes – only ~100 cause most human illness
- 2,378 cases reported in 2023 in Ontario
  - 35.5% *Salmonella* Enteritidis
  - 5.8% *Salmonella* Typhimurium
  - 5.5% *Salmonella* Braenderup
- Incubation period varies but generally from 6 hours – 7 days (usually 12-36 hours)
- Reservoir varies by serotype, includes cats, dogs, livestock, poultry, reptiles and other animals

What are Reptiles?[4]

- Squamates: snakes, lizards and tuataras
  - Common snakes kept as pets: ball pythons, carpet pythons, boas, corn/rat snakes and king snakes
  - Common lizards: leopard geckos, crested geckos, bearded dragons, monitors and tegus
- Chelonians: turtles and tortoises
  - Common turtles: red eared sliders, alligator snapping turtles, false map turtles
  - Tortoises: leopard, Hermanns, Russian, sulcata or “spur-thighed”
- Crocodilians: crocodiles, alligators, caiman
  - Less common species: spectacled caiman, dwarf caiman, American alligator

What are NOT Reptiles?

NOT reptiles

- X Amphibians
- X Fish
- X Birds

ALL reptiles

- ✓ Have thick, scaly integuments that must be shed
- ✓ Are dependent on external heat for metabolic processes, but are not necessarily the same temperature as the environment

Salmonella and Reptiles[5]

- *Salmonella* can be a normal component of reptile gastrointestinal flora
- *Salmonella* can also be a significant pathogen for reptiles, especially stressed and sick reptiles
- *Salmonella* can come from within or from external sources
- Most normal, healthy reptiles will not show signs of gastrointestinal colonization, however suboptimal husbandry and stress can increase likelihood of shedding
- Stress may also permit extra-intestinal colonization with microbial flora shifts
- Attempts to eliminate *Salmonella* from reptiles and their eggs are not recommended

Clinical Signs of Illness in Reptiles[6]

- Common signs of suboptimal husbandry include lethargy, inanition, retained skin patches, including on eyes and ornamentation if appropriate, swollen puffy eyelids or gingiva, loss of or discoloration of toes or tail tips, patchy erythema or petechiae.
- Sudden death or sepsis is the most common presentation of *Salmonella* infection, although clinical presentations of *Salmonella* spp. overlap with those of other bacterial pathogens
- Very commonly have concurrent nutritional deficiencies
- Snakes very commonly show severe stomatitis and osteomyelitis
- Most species will show sepsis, or pneumonia, abscess formation, lethargy, cachexia, cloacitis/pericloacitis or osteomyelitis.

Reporting of *Salmonella* Isolated from Reptiles in Ontario

- Private veterinarians may submit reptile and amphibian specimens to Ontario veterinary diagnostic laboratories as part of animal health exams
- Specimens are typically submitted from sick or deceased animals
- *Salmonella* positives are reported to OMAFA (serotype only), allowing for assessment of common serotypes and implicated species
- Pooled feces from live animals may be tested with enrichment – unreliable as shedding is intermittent and generally only indicate normal carrier state
- Many samples reported to OMAFA come from wound/abscess culture or from internal organs, which are more likely to yield pathological *Salmonella*

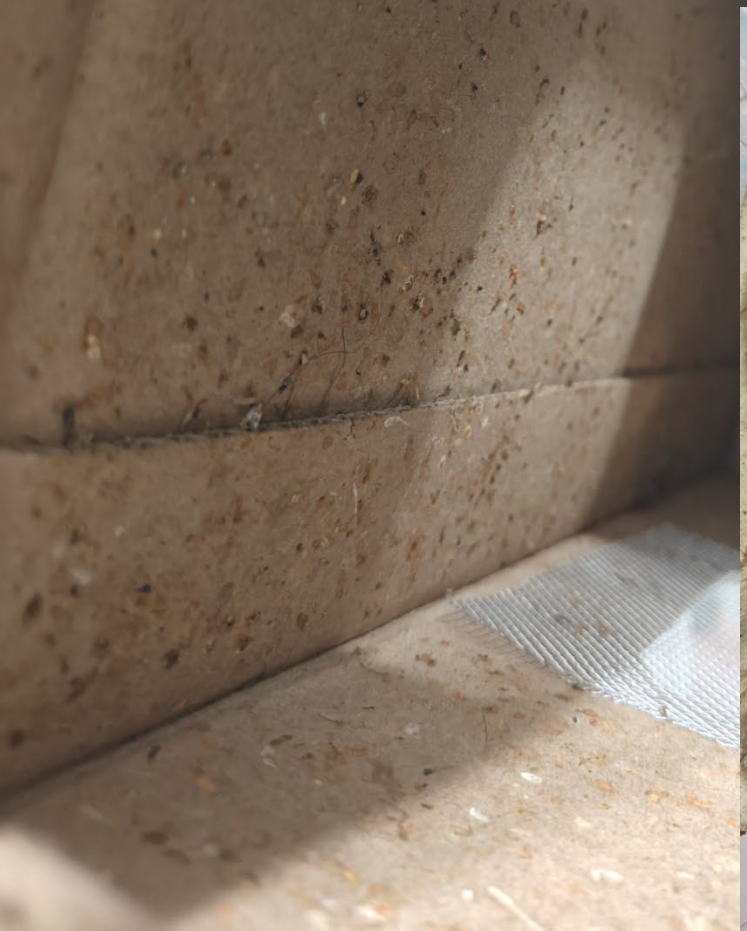
Turtles and *Salmonella*[8]

- The United States Food and Drug Association (FDA) banned the sale of small turtles to the public in 1975 as turtle-associated *Salmonella* infections were so common
- Small turtles are those with a carapace <4 inches long
- National outbreaks linked to small turtles sold illegally continue to occur, highlighting enforcement challenges
- Ownership restrictions in Canada are decided at a municipal level

Reptile Diet – Crickets and Other Insects

- Enormous diversity – two species of cricket (banded and house), discoid roaches, mealworms, superworms, horn worms, wax worms, black soldier fly larvae and fruit flies (two species)
- May be raised on scraps (roaches, black soldier fly larvae) or specific diets (fruit flies, crickets)
- Insects themselves may be natural reservoirs of *Salmonella* or colonies may be easily contaminated

Packaging from typical bulk cricket purchases

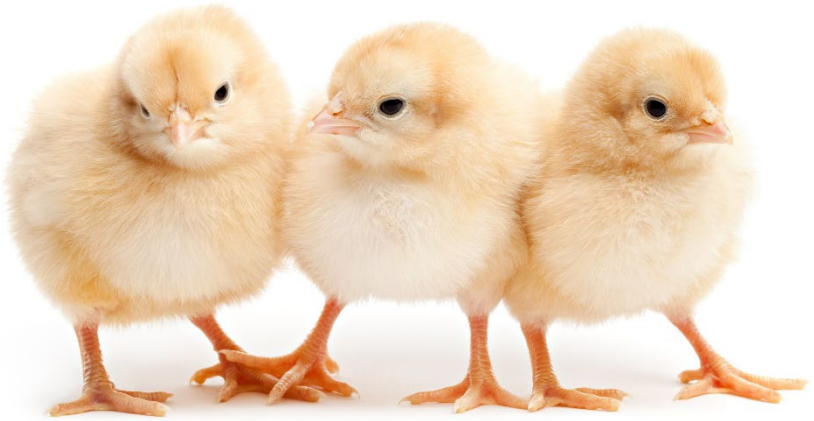


Feeder Vertebrates[9] (1 of 3)

- Many species consume these – not just reptiles, i.e., exotic cats, ferrets, raptors
- Common rodent species used as feeder vertebrates include house mice, Norway rat and African soft-furred rat/multimammate mouse
- Generally raised in high density colonies, often in sheds with additional ventilation in vertical racks
- Generally fed a mixture of commercial pellets with/without dog kibble and/or bird seed mixes
- Gravity fed water systems most common
- Biosecurity is low, generally established from pet trade and exposure to wild rodents common
- Best Management Practices for feeder rodent production and distribution

Feeder Vertebrates (2 of 3)

- Chicks – may be culls from layer industry or raised specifically for reptile food
- Chicken chicks and quail chicks most common, with ducks sometimes produced
- Larger reptile species may consume guinea pigs, rabbits and/or small pigs
- Live feeder fish may also be used – generally cyprinids (“baitfish,” small goldfish, rosy red/fathead minnows) but also sometimes hybrid livebearer species
- Long-term cyprinids diet can lead to severe nutritional deficiencies



Feeder Vertebrates (3 of 3)

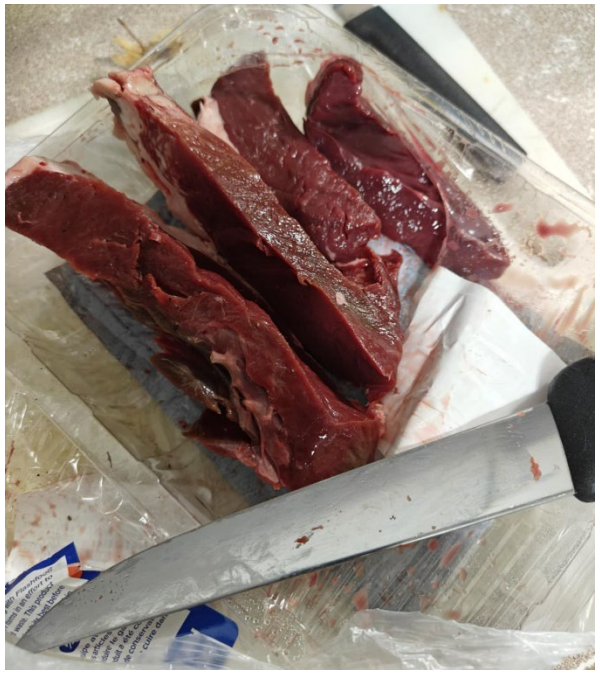
- Most species generally killed with carbon dioxide (not AVMA recommended) and frozen intact when not fed live
- Feeding live prey can increase oral trauma from being attacked by feeder prey if the reptile is not hungry
- Poor freezing practices can increase autolysis
- Freezing (and drying) do not reliably inactivate or kill *Salmonella*

“New” Diet Formulations

- Powder-to-gel diets are a mainstay for some species (crested geckos); also increasing in popularity as a supplement for other species to diversify diets or for convenience
  - Blends of protein sources, fruit, other carbohydrates and vitamin/mineral supplements, mixed with water to form a thick milkshake consistency or gelatin-like state.
- Increasing interest in what used to be called “snausages” – extruded carnivore diets that may incorporate fish, frog meat, poultry, or rodents with vitamin and mineral supplementation, set into a thick gelatin and cut or shaped
  - Often stored fresh or frozen
- Both types of diets produced without ingredient regulatory oversight and not heat treated

Reptile Diet – Home-Prepared Diets

- Some owners “cut” relatively expensive items like feeder animals with grocery store products such as organ meat, eggs or egg product, drumsticks, ground meat or processed carcasses
- Many herbivorous animals fed green produce from grocery stores
- Some people feed expired items thinking they are safe for reptiles
- Will also sometimes feed items like baby puree products that are easily contaminated after opening
- So-called “San Diego Zoo recipe” for large carnivorous lizards consists of ground turkey, baby food and human vitamin and mineral supplements



Transmission of *Salmonella* from Reptiles to People[7]

- *Salmonella* may be present in reptile gastrointestinal flora and can be shed into the reptile enclosure/environment, prompted or exacerbated via stress/handling
- People may be exposed to *Salmonella* through direct or indirect contact, including with the reptile, its environment/enclosure or feed
- Feeder prey (e.g., mice, rats, crickets) can also be a source of *Salmonella*
- People may be exposed to *Salmonella* from cross-contamination or poor hand hygiene
- Roaming of reptiles outside of their enclosure may result in contamination of environmental surfaces

Public Health Investigations

- Gather information about reptile species and details of interaction
- Gather information about reptile diet and food handling practices
- Assess whether exposure may have occurred through direct or indirect contact
- Ask about other susceptible individuals in the household (provide education)

Environmental Testing[10,11]

For outbreak and case investigations where reptiles are a suspected source, testing of environmental swabs may be useful

If *Salmonella* is identified by bacterial culture, serotyping and whole genome sequencing is performed

Isolates related with 0-10 wgMLST alleles are considered related

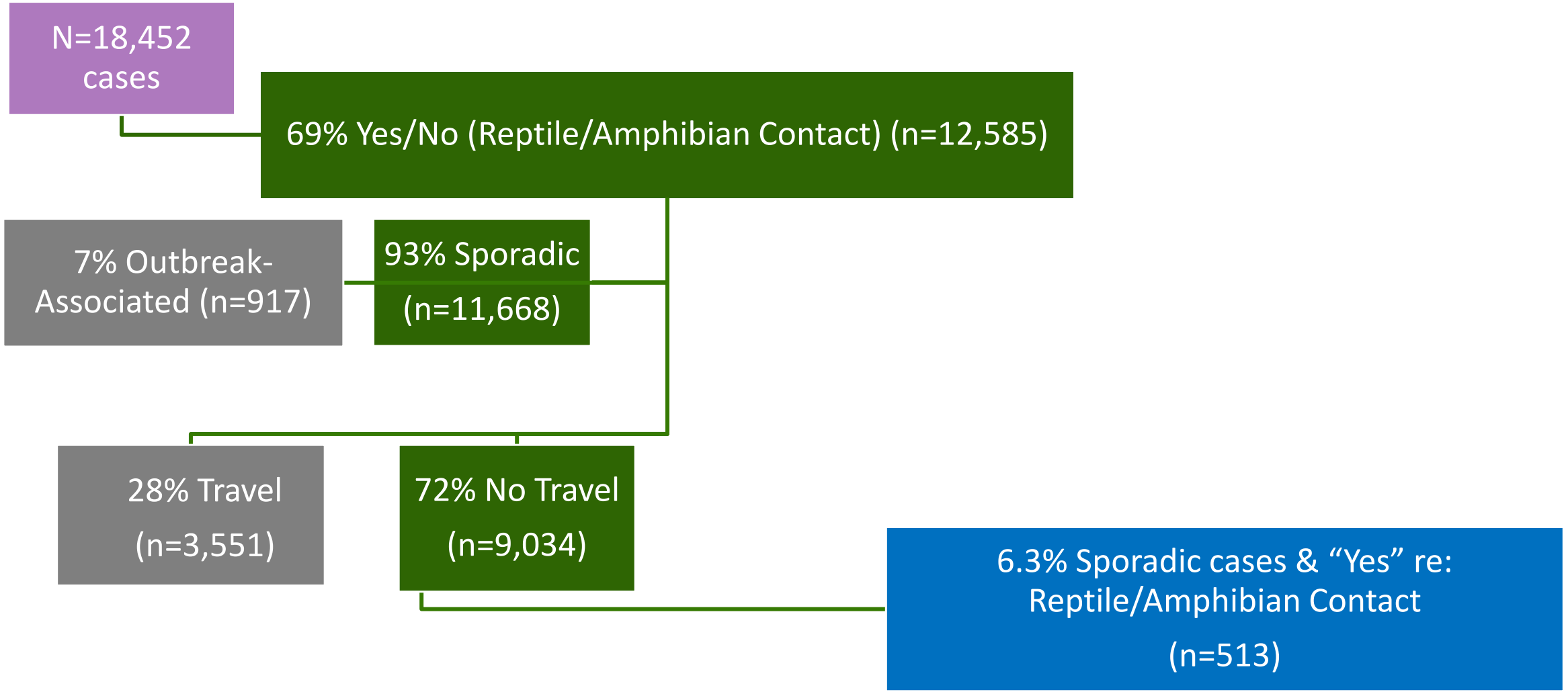
Recent National Outbreaks Associated with Pet Reptiles[12]

- 2024 –*Salmonella* Muenchen (geckos)
- 2024 –*Salmonella* Lome infections (geckos)
- 2024 –*Salmonella* Typhimurium/*Salmonella* I 4,[5],12:i:- (snakes and rodents)
- 2023 – *Salmonella* outbreaks (United States) (small turtles)
- 2021 –*Salmonella* Typhimurium (snakes and rodents)

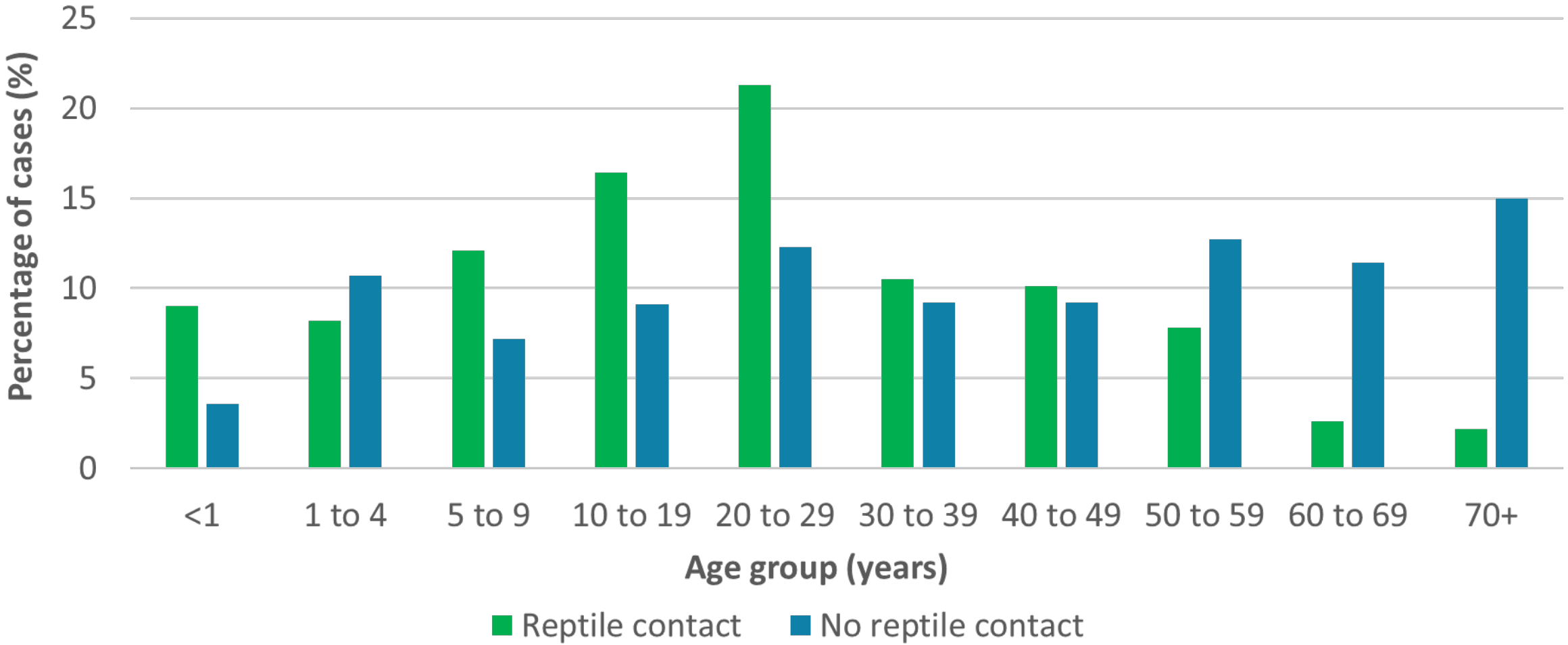
Our Study…

- Retrospective analysis of surveillance data for human *Salmonella* cases in Ontario from 2015-2022
- Purpose: explore proportion of cases reporting reptile contact, assess reptile types and serotypes associated with human infection, compared to reptile isolates
- Human case data included: *Salmonella* serotype, onset date, risk factor data: contact with reptiles or amphibians (yes/no), travel (yes/no), reptile type
- Serotypes and reptile types for those reporting domestic reptile or amphibian exposure were compared with veterinary *Salmonella* isolates reported during the same period
- Manuscript accepted for publication in *Emerging Infectious Diseases*

Our Findings – Human *Salmonella* Cases



Age distribution of sporadic *Salmonella* cases in Ontario with and without reptile/amphibian contact, for those with no recent travel (2015-2022) (n=8,148)



Results

- Our analyses focused on those n=513 sporadic cases who reported reptile/amphibian contact in the week prior to symptom onset, but did not travel during that week (i.e., reptile exposure occurred locally)
- Overall, 6.3% of sporadic cases reported reptile/amphibian contact. By comparison…

Foodbook Report Estimates

- 2.1% reptile contact, 1.0% amphibian contact (2015)[13]
- 2.7% reptile/amphibian contact (2024)[14]

Reptile Types Reported by Cases

- Reptile types commonly reported by cases:
  - Lizards (46%); Bearded dragons, other lizards, geckos, chameleons and iguanas
  - Snakes (27%); Corn snakes, pythons/ball pythons, boas
  - Turtles/tortoises (29%)
  - Amphibians (11%)
  - Multiple reptile types (12%)

Salmonella serotypes Isolated from those sporadic human *Salmonella* cases in Ontario who reported reptile/amphibian contact and no recent travel (2015-2022) (n=513)

94 unique *Salmonella* serotypes reported

45 serotypes (48%) only reported once

Most human isolates (95%, n=487) *S. Enterica* subsp. *enterica*

Common Serotypes - Human Cases With Reptile Contact

- *S*. Typhimurium (n=81)*
- *S*. Enteritidis (n=76)*
- *S*. 4,[5],12:i:-/4,12:i:- (n=29)*
- *S*. Oranienburg (n=27)*
- *S*. Muenchen (n=26)*
- *S*. Heidelberg (n=16)*
- *S*. Paratyphi B var. Java (n=16)

* Mouse serotype

Note: We did not adjust for other risk factors, i.e., associations do not imply causation!

Reptile and Serotype Associations (Ontario; 2015-2022)

88% of *S*. Paratyphi B var. Java cases (n=14/16) reported snake contact

100% of *S*. Chester (n=5/5), 82% of *S*. Tennessee (n=9/11), and 71% of *S*. Cotham (n=5/7) cases reported bearded dragon contact

80% of *S*. Agbeni cases (n=4/5) reported turtle contact

Salmonella Serotypes Isolated from Reptiles in Ontario (2015-2022)

35 unique *Salmonella* serotypes isolated

29 serotypes (83%) only reported once

Most reptile isolates *S. Enterica* subsp. *enterica* (30%, n=14)

or *S. Enterica* subsp. *arizonae* (28%, n=13)

Reptile and Amphibian Veterinary Isolates in Ontario (2015-2022)

- 46 *Salmonella* isolates from reptile specimens were reported to OMAFA by veterinary diagnostic labs in Ontario from 2015-2022
- There were no amphibian submissions over this period
- 80% of reptiles were privately owned
  - *Salmonella* was most commonly isolated from bearded dragons
- 20% were owned by zoological institutions
  - *Salmonella* most commonly isolated from Eastern Massasauga rattlesnakes

  - Most *Salmonella* isolates were from snake submissions (63%; n=29/46)

Reptile *Salmonella* Isolates and Reptile Diet Type

- Obligate carnivores were more likely to have *Salmonella* isolated (n=32, 70%) compared to omnivores (n=7, 15%) or herbivores (n=4, 9%) and species that could not be classified (n=3, 6%)
- All snakes are obligate carnivores, and mice are also a reservoir for *Salmonella*
- Bearded dragons are very commonly bred overseas and imported to Canada through retail pet chains
- Increasing interest in powder-to-gel diets, alternative insect species and artificial prey may drive *Salmonella* infection

Public Health Investigation Tips[15]

- ✓ Use the PHO Salmonellosis Investigation Tool to capture risk factor information during case investigations
- ✓ If clients report contact with reptiles/amphibians, collect information re: reptile type(s), purchase location and date, diet, and nature of exposure
- ✓ Consult with PHO's laboratory what specimens may be submitted for testing
- ✓ Consider environmental swabs of 'high-touch' surfaces within the reptile enclosure
- ✓ Fecal specimens and cloacal swabs are less reliable than environmental swabs

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Public Health Inspector's Guide to Environmental Microbiology Laboratory Testing

© City of Toronto Archives, fonds 200, series 372, subseries 32, item 130.

Best Practice

Current as of September 13, 2024

Infection Control Tips for Reptile Owners

- ✓ Change clothing after holding/handling reptiles, their food or environment
- ✓ Wash hands after handling reptiles, their food or environment
- ✓ Supervise interactions between children and reptiles
- ✓ Restrict roaming of reptiles
- ✓ Clean and disinfect contaminated surfaces
- ✓ Avoid bathing reptiles/amphibians in kitchen sink or near food preparation areas
- ✓ Use dedicated utensils/containers for reptile feedings, products and care

Infection Control Tips for Reptile Breeders/Sellers

- ✓ Change clothing after holding/handling reptiles, their food or environment
- ✓ Wash hands after handling reptiles, their food or environment
- ✓ Prioritize preventive veterinary care
- ✓ Environmental cleaning and disinfection
- ✓ Be aware that reptiles can be colonized with *Salmonella* and that stress can increase fecal shedding
- ✓ Provide infection control information to clients at point of sale

Key takeaways

- Reptiles are a natural reservoir for *Salmonella*
- Reptiles are becoming increasingly popular as pets
- Exposure may occur directly or indirectly
- Be aware of reptiles/pets and their food/prey as a potential source of exposure
- Environmental swabs can identify reptiles as a potential source of exposure
- Current and prospective reptile owners should be educated on zoonotic disease risks associated with reptile ownership, and steps that can be taken to reduce infection transmission

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