Veterinary Microbiology 170 (2014) 167–171

Contents lists available at ScienceDirect

Veterinary Microbiology

journal homepage: www.elsevier.com/locate/vetmic

Short Communication

Salmonella serotypes in reptiles and humans, French Guiana

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ARTICLE INFO

Article history:
Received 19 September 2013
Received in revised form 9 January 2014
Accepted 19 January 2014

Keywords:
Salmonella
Reptiles
Humans
Serotypes
Zoonosis
French Guiana

ABSTRACT

In French Guiana, a French overseas territory located in the South American northern coast, nearly 50% of *Salmonella* serotypes isolated from human infections belong to serotypes rarely encountered in metropolitan France. A reptilian source of contamination has been investigated. Between April and June 2011, in the area around Cayenne, 151 reptiles were collected: 38 lizards, 37 snakes, 32 turtles, 23 green iguanas and 21 caimans. Cloacal swab samples were collected and cultured. Isolated *Salmonella* strains were identified biochemically and serotyped. The overall carriage frequency of carriage was 23.2% (95% confidence interval: 16.7–30.4) with 23 serotyped strains. The frequency of *Salmonella* carriage was significantly higher for wild reptiles. Near two-thirds of the *Salmonella* serotypes isolated from reptiles were also isolated from patients in French Guiana. Our results highlight the risk associated with the handling and consumption of reptiles and their role in the spread of *Salmonella* in the environment.

1. Introduction

Salmonella is a major foodborne pathogen found worldwide. Non-typhoidal *Salmonella* causes 93.8 million human cases of gastroenteritis and 155,000 deaths annually worldwide (Majowicz et al., 2010). The *Salmonella* genus includes two species: *S. enterica* and *S. bongori*. *S. enterica* is subdivided into six subspecies: *enterica* (former subgenera I), *salamae* (II), *arizonae* (IIIa), *diarizonae* (IIIb), *houtenae* (IV) and *indica* (VI). Over 2600 serotypes were identified according to the White–Kauffmann–Le Minor scheme (Grimont and Weill, 2007). The digestive tract of warm-blooded animals is the main reservoir of *Salmonella* subspecies *enterica* (Grimont and Weill, 2007), while other subspecies are mainly found in cold-blooded animals. Reptiles can harbour multiple subspecies and serotypes simultaneously (Pedersen et al., 2009). Most human salmonellosis is associated with eating contaminated raw or undercooked food of animal origin. Other transmission routes exist: human-to-human contacts, consuming contaminated vegetables, water (Wegener et al., 2003) and direct contact with infected animals, including pets. In western countries serotypes from reptiles are rarely encountered in humans (Woodward et al., 1997; O'Byrne and Mahon, 2008). Within the European Union, it is estimated that <1% of human salmonellosis are associated with reptiles (Bertrand et al.,

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http://dx.doi.org/10.1016/j.vetmic.2014.01.024

2008). Furthermore, serotypes from reptiles seem to be responsible for more severe complications and hospitalizations (Cieslak et al., 1994).

In French Guiana, a French overseas territory (around 85,000 km^2) located in South America, nearly 50% of *Salmonella* isolates from human belong to serotypes rarely encountered in metropolitan France.

The objectives of this study conducted around Cayenne, the main city of French Guiana, were to assess *Salmonella* carriage by different reptile species living in different ecosystems (zoo, forest, commensal environment or caged/contained in or around human dwellings) and to compare reptilian and human serotype distributions.

2. Materials and methods

2.1. Surveillance of human Salmonella infections

In France, human *Salmonella* surveillance is a voluntary laboratory-based network headed by the French National Reference Center for *Salmonella* (FNRC-Salm). Participating laboratories annually send 8000–10,000 *Salmonella* isolates to the FNRC-Salm, which serotypes them and runs weekly outbreak-detection algorithms (David et al., 2011). In 2011, all the medical laboratories from French Guiana (8 private biomedical laboratories and 2 public hospitals) participated in the present study.

2.2. Frequency of Salmonella carriage in reptiles

From 5 April to 6 June 2011, reptiles were captured from more-or-less human-occupied environments around Cayenne. Four living conditions were defined: zoo, for captive animals in the zoo; forest, for reptiles captured there; commensal environment, for reptiles living in or around human lodgings (e.g. *Hemidactylus mabouia*); reptiles caged (e.g., snake terrarium) or contained in a space from which there is no egress (e.g., turtles within a garden) in or around a private home.

Cloacal swab samples were collected and kept at room temperature (26 ± 4 °C) for a maximum of 48 h. Samples were incubated in 9 ml of buffered peptone water for 16–20 h at 37 °C. Three drops of the pre-enrichment broth were inoculated onto specific medium (Hektoen agar, BioMérieux, Marcy L'Etoile, France) and incubated at 37 °C for 21–27 h. Lactose-negative colonies were subjected to the urease test and incubated at 37 °C for 21–27 h. When urease was negative (suspected *Salmonella*), biochemical identification of an isolated colony was pursued with the API 20E Kit (BioMérieux). Isolates were sent to the FNRC-Salm (except subspecies *arizonae* determined by the API 20E kit) for serotyping according to the White–Kauffmann–Le Minor scheme. All strains underwent antimicrobial-susceptibility testing with the disk-diffusion method on Mueller-Hinton agar (Bio-Rad, Marnes-La-Coquette, France) against 16 antimicrobials (amoxicillin, streptomycin, spectinomycin, azithromycin, kanamycin, netilmicin, amikacin, tobramycin, gentamicin, nalidixic acid, ofloxacin, ciprofloxacin, chloramphenicol, sulfonamides, trimethoprim and tetracycline), according to the guidelines of the French Society for Microbiology (available at: http://www.sfm-microbiologie.org/).

Reptile species were grouped as: caimans, snakes, green iguanas (*Iguana iguana*), other lizards and turtles. Statistical analyses were computed with Stata® v9.0 Stata Corp; chi^2 or Fisher's exact tests were used.

3. Results

During the study, 151 reptiles (Table 1) were collected. They were distributed in habitats as follows: 34.4% (52/151) from zoo, 31.8% (48/151) from forest, 19.9% (30/151) in commensal environment and 13.9% (21/151) caged/contained in or around a private home.

The frequency of *Salmonella* carriage in cloacal samples was 23.2% (35/151, 95% CI: 16.7–30.4), ranging between 14.3% and 32.4%, depending on the type of reptile (Table 1), but did not differ significantly ($p = 0.5$). Habitat was significantly associated with *Salmonella* carriage ($p < 0.001$), with frequencies of 5.8–39.6%. The frequency of carriage was higher for reptiles captured in forests and caged/contained in or around private homes.

S. enterica subspecies represented 47.2% (17/36) of all isolates (Table 2). Serotyped strains (23/36) belonged to both subspecies *enterica* (17/23, 73.9%) and *houtenae* (6/23, 26.1%) and were susceptible to all antibiotics tested. One

Table 1
Reptile *Salmonella* carriage according to reptile type or living conditions.

Parameter	*N* (%)	*Salmonella* frequency		*p*	OR [95% CI]
		n	% (95% CI)		
Reptile				0.5	
Caimans	21 (13.9)	3	14.3 (3.0–36.3)		1.0
Turtles	32 (21.2)	6	18.8 (7.2–36.4)		1.4 [0.3–6.3]
Green iguanas	23 (15.2)	6	26.1 (10.2–48.4)		2.1 [0.5–9.8]
Other lizards	38 (25.2)	8	21.1 (9.6–37.3)		1.6 [0.4–6.8]
Snakes	37 (24.5)	12	32.4 (18.0–49.8)		2.9 [0.7–11.7]
Total	151 (100)	35	23.2 (16.7–30.4)		
Living conditions				<0.001	
Zoo	52 (34.4)	3	5.8 (1.2–15.9)		1.0
Commensal environment	30 (19.9)	5	16.7 (5.6–34.7)		3.3 [0.7–15.1]
Caged/Contained	21 (13.9)	8	38.1 (18.1–61.6)		10.3 [2.4–44.2]
Forest	48 (31.8)	19	39.6 (25.8–54.7)		11.3 [3.1–41.6]
Total	151 (100)	35	23.2 (16.7–30.4)		