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Salmonella Typhimurium in Hihi, New Zealand

To the Editor: The recent finding of a previously unrecorded *Salmonella* strain in an endangered New Zealand passerine (the hihi, *Notiomystis cincta*; [*1*]) offers the rare opportunity to observe the initial arrival and pathology of an epizootic and to determine its population-level effect. Over 8 days in February 2006, 6 freshly dead hihi were discovered in a free-living island population. Pathologic findings were similar: birds were in good body condition with substantial subcutaneous fat reserves and no gross lesions in the crop, indicating death from a highly pathogenic disease. Histopathologic examination showed septicemia and inflammatory necrosis of organs, particularly the liver and spleen, typical of salmonellosis in birds (*2*). Microbiologic examination of liver samples isolated heavy growths of the bacterium *Salmonella enterica* serotype Typhimurium DT195. During the same period, 3 more dead hihi were found, but they were too decomposed for postmortem examination.

Hihi are nectar-feeders that declined to near extinction after European colonization of New Zealand and survived on a single island refuge (Hauturu). Since 1980, 14 attempts have been made to reintroduce the species to 6 other sites, resulting in 3 new populations that persist with management. The *S.* Typhimurium DT195 outbreak occurred within a reintroduced population on Tiritiri Matangi Island. Management includes providing supplementary food (sugar water) diluted with local rain water; feeders are sterilized before each use.

Because disease in hihi is closely monitored, the outbreak indicates that *S.* Typhimurium DT195 is a novel serotype for this species. During December 2005, fecal screening of 18 broods (37 nestlings) from Tiritiri Matangi Island found no evidence of enteric pathogens; screenings in February and May 2005 (40 adult and juvenile birds) from Tiritiri Matangi Island similarly returned negative results. Screening in all hihi populations during 2004 also found no evidence of *Salmonella* infection (32 adults and juveniles at Tiritiri Matangi, 29 at Hauturu, and 27 at Kapiti), and a 15-year pathology database from 230 dead hihi collected across these populations and a captive breeding facility lists no salmonellosis cases (J.G. Ewen and M.R. Alley, unpub. data).

Documentation of the emergent stages of infectious disease in endangered species is rare (*3*,*4*). This bacterium strain is absent from New Zealand's livestock and wildlife (www.surv.esr.cri.nz/enteric_reference/non human_salmonella.php). Nontyphoid *Salmonella* spp. are a major health concern worldwide (*5*), and New Zealand conducts intensive surveillance to maintain food safety. The New Zealand Wildlife Health Centre has not reported *S.* Typhimurium DT195 despite necropsies of >3,000 wild birds during 1996–2006, which suggests this strain is rare in New Zealand, despite its presence in other countries (*6*).

S. Typhimurium DT195 has been detected in 3 human patients in New Zealand (1 each in 2002, 2003, and 2006). The *S.* Typhimurium DT195 isolated from hihi in the February 2006 outbreak were indistinguishable from those isolated from the human case-patient in 2006 (see [*2*] for methods). Tiritiri Matangi is an isolated island nature reserve 3 km off the New Zealand coast, which prevents movement of hihi to other areas. How this strain appeared in a human patient and as an epizootic in an isolated island nature reserve is intriguing. The most recent human case was diagnosed on the North Island of New Zealand, but the person was not living in close proximity to the birds. Tiritiri Matangi receives ≈30,000 human visitors per year, but whether the person with *S.*

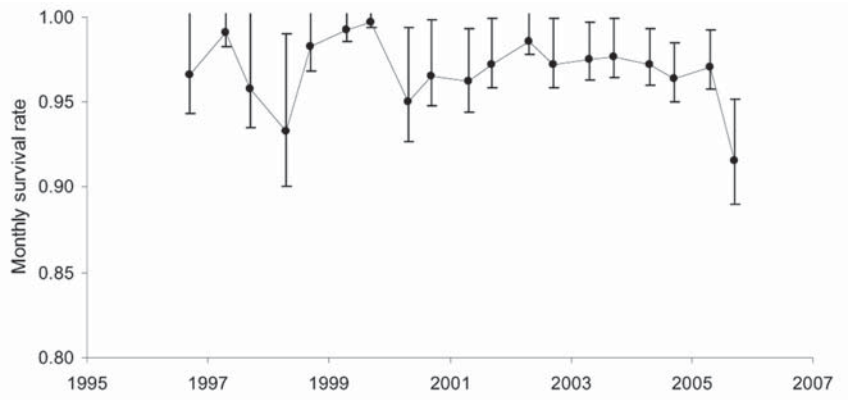

Figure. Survival rates from September–February and February–September among hihi in New Zealand during 1996–2006, estimated by using mark–recapture analysis, show that the transmission of *Salmonella* Typhimurium DT195 to hihi during the February 2006 epidemic caused a substantial drop in population. Bars indicate 95% confidence intervals.

Typhimurium DT195 ever visited is not known. An unidentified infection source may be present in New Zealand that periodically spills over into alternate host species. Given their historic isolation, hihi may have low or no exposure to many diseases, which makes negative reactions more likely (*7*).

The transmission of *S.* Typhimurium DT195 to hihi caused a substantial drop in their population (Figure). The 9 bodies recovered represent a small proportion of the birds that died, given the difficulty of recovering dead birds (*8*). We used mark–recapture analysis (*9*) to estimate that adult survival probability was 0.64 (95% confidence interval [CI] 0.53–0.74) from September 2005 through February 2006, compared with an expected survival of 0.87 (95% CI 0.85–0.89), according to data from the previous 10 years (data not shown). The quotient of these 2 probabilities is 0.74 (95% CI 0.60–0.84); hence, we can infer that ≈26% of birds were killed by the epizootic.

With such high virulence, fade-out may occur as susceptible individuals are rapidly removed from the population (*10*). Subsequent monitoring has failed to detect further evidence of *S.* Typhimurium DT195. This apparent fade-out mirrors classic predictions from epidemiology (*10*). It is unknown whether the pathogen resides in resistant hihi or whether threats from the unknown source remain.

The key issues for endangered species management are identifying the risk of pathogens entering a host population and the probability that this occurrence would result in host extinction (*3*). The 2006 salmonellosis outbreak in hihi could easily have remained undetected, leaving conservation managers unaware of what caused the population decline. How often this occurs in poorly monitored wildlife is unknown. This study shows the need for increased awareness of these processes when considering biodiversity conservation.

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Travel-related *Salmonella* Agama, Gabon

To the Editor: Traveler's diarrhea affects >50% of travelers to regions such as sub-Saharan Africa (*1*). Worldwide, enterotoxigenic *Escherichia coli* is the leading bacterial pathogen that causes traveler's diarrhea, followed by *Campylobacter jejuni* and then *Salmonella* spp., which are the causative pathogens for ≥25% of traveler's diarrhea in Africa (*1*). Nontyphoidal salmonellosis is mostly caused by the *Salmonella* serotypes Enteritidis and Typhimurium (*2*). To our knowledge, only a few cases of salmonellosis due to *S.* Agama have been reported in medical literature, none as a travel-related disease (*3*,*4*).

S. Agama was characterized in 1956 as a new serotype of *Salmonella enterica* from the feces of the agama lizard (*Agama agama*) in Nigeria (*5*). Subsequently, *S.* Agama was isolated from geckos and mammals in Africa (*4*,*6*,*7*) and the United Kindgom (*8*,*9*). Human infections with *S.* Agama were once reported in Nigeria and related to the lizards as possible reservoirs (*4*). Another clinical case of *S.* Agama infection was described in France in a 9-month-old child with fever and diarrhea (*3*); fruits imported from Africa were discussed as potential source of infection. We report what is, to our knowledge, the first travel-related case of salmonellosis due to *Salmonella* Agama experienced by a tourist who had traveled to Gabon in central Africa.

A previously healthy 25-year-old man in Germany sought treatment for 2 episodes of intermittent fever ≤39°C, as well as headache, nausea, abdominal pain, diarrhea, arthralgia, and cough. Symptoms started the day he returned from a 1-month trip to Gabon, a country in central Africa, where he stayed with a friend who lives near the Albert Schweitzer Hospital in Lambaréné and took occasional excursions to other areas.

Before traveling, the patient had been immunized against hepatitis A, hepatitis B, yellow fever, polio, typhoid fever, tetanus, measles, and mumps; he reported taking atovaquone-proguanil for malaria prophylaxis during his first 3 weeks in Gabon. While in Gabon, he frequently drank tap water, ate food sold by street vendors, and had repeated fresh water contact while swimming in the Ogooué River. He exhibited no symptoms during his trip.

His first examination was performed 2 weeks after his return to Germany and the onset of symptoms. Physical examination showed no pathologic findings, malaria was excluded by repeated thick blood smears, and in the absence of abnormal laboratory findings a common cold disease was assumed on clinical grounds. No specific treatment was prescribed, and the patient recovered from symptoms except for intermittent mild diarrhea.

Four weeks after his return to Germany, a second episode with reappearance of all former symptoms led to a new examination. At this time, the patient was afebrile, and physical examination showed no pathologic findings. Laboratory values were within the normal range except for C-reactive protein, which was elevated at 47mg/dL (normal value <5 mg/dL). Pneumonia was excluded by radiography, and a stool sample was obtained for parasitologic examination and bacterial culture. The patient was treated with clarithromycin, 500 mg orally twice a day for 7 days, for a presumed upper respiratory tract infection. The patient's symptoms disappeared.

Stool sample test results were negative for intestinal helminths and other parasites. However, growth of *Salmonella* species was observed in 1 culture. The isolate was characterized as *Salmonella* Agama (*S. enterica* subspecies *enterica* serotype Agama 4,12: i: 1,6). It was sensitive to ampicillin, cefotaxime, cefuroxime, ceftriaxone, imipenem, ciprofloxacin, gentamicin, trimethoprim-sulfamethoxazole, and fosfomycin but resistant to clarithromycin (MIC 96 mg/L). Five weeks after clinical resolution, further stool samples were found to be negative for any enteric pathogen.

In the light of the microbiologic evidence of *S.* Agama infection, we interviewed the patient about any consumption of meat or poultry and contact with animals. The patient reported no contact with animals during and after his trip to Gabon and said he is a vegetarian who abstains from consumption of any meat, including poultry. In Gabon, lizards are plentiful around all habitations, including the terrace of the house where the patient stayed; he reported that he ate sitting on the floor of the terrace. Lizards are also sometimes seen in food displays at street markets, including among foods that are commonly eaten uncooked (Figure).

Given microbiologic results and travel history, *S.* Agama was the most likely cause for the gastroenteritic and unspecific symptoms experienced by our patient. We may speculate about transmission of *S.* Agama by direct or indirect contact with lizards, but other routes of transmission cannot be ruled out.

Gastrointestinal and unspecific symptoms lasted 2 weeks with un-