Salmonella in Two Gecko Species on the Island of Hawaii

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INTRODUCTION

The occurrence of *Salmonella* and other enteric pathogens in reptiles has been reported by Iveson, Mackey and Bamford (1969) and Kourany, Myers and Schneider (1970). Numerous reptilian species were reported as carriers of *Salmonella*. While reptiles were known as carriers of *Salmonella* their epidemiological role in human salmonellosis was unclear until outbreaks from contact with freshwater turtles was reported by Williams and Hedson (1965). Kourany and Telford (1981) suggested that gecko lizards might infect man through contamination of food and eating utensils with their excreta.

In Hawaii, geckos are extremely common throughout the islands. Just about every dwelling has its population of geckos. While there are seven gecko species in Hawaii, only two, *Hemidactylus frenatus* and *Lepidodactylus lugubris*, are common to households. The geckos are insectivorous and most often station themselves along walls and window sills where there is sufficient light to attract insects. Although they are active primarily at night, their presence is revealed by their extensive fecal droppings. Since these geckos are often found inside the home in areas where food is prepared or stored, it appears the opportunity for gecko to human transmission of salmonellosis might exist. An investigation of a salmonellosis outbreak in Dar es Salaam, Africa by Mackey (1955) indicated household geckos as the source of contamination.

In our study, we attempted to establish whether *Salmonella* bacteria were present in the two species of household geckos, *H. frenatus* and *L. lugubris*, and in their droppings.

MATERIALS AND METHODS

Collection and Analysis of Gecko Lizards

Geckos are normally active only at night. Hence, collecting was initiated usually well after dark. The geckos were most common around older buildings especially those with corrugated iron roofing since the space between the roof covering and walls offered numerous crevices in which the geckos could hide. The geckos were most numerous around light fixtures and window areas. These well-lit areas served as established feeding sites and were heavily marked by gecko excreta.

Once the feeding sites were located the geckos were spotted with flashlights and captured by knocking them off the wall with heavy rubber bands. The rubber band was stretched over the index finger and simply aimed at the gecko. With a bit of practice, a surprising degree of accuracy was attained. When hit, the stunned gecko would fall off the wall and could easily be captured. Later, a water spray was found to be equally effective. The spray loosened the geckos' grip causing them to fall off the wall; this method had the added advantage in that the animals were recovered undamaged.

The captured animals were placed in individual plastic pouches and taken back to the laboratory in a styrofoam chest. Upon arrival at the laboratory, the pouches with the geckos were refrigerated overnight at 4C. By next morning the geckos treated in this fashion were in a state of stupor. Before initiating dissection, each gecko was killed by severing the spinal cord just behind the neck. With the animal pinned on its back, the abdomen was swabbed with 70 percent alcohol, then an incision was made to expose the internal organs. A hemostat was clamped onto the esophagus just anterior to the stomach, while the lower intestine was clamped near the anal opening. The entire gut was then severed and removed. The gut contents were then squeezed out, and transferred, along with the minced gut, to 10 ml of Tetrathionate Broth with Brilliant Green dye and iodine. After incubation for 24 hours at 37C a loopful of the enrichment broth was streaked onto Brilliant Green Agar (BGA), MacConkey Agar and SS Agar and incubated for 24 hours at 37C. Suspected salmonella-like colonies were restreaked onto BGA for further testing. Confirmation of *Salmonella* was made by testing cultures on Triple Sugar Iron and using a diagnostic test system, either Roche Enterotube II or General Diagnostic's MICRO-ID system. Final confirmation was made with *Salmonella* Polyvalent O and Vi antisera (Difco). In some cases suspected colonies were tested directly with the antisera for rapid confirmation.

Collection and Analysis of Gecko Droppings

Fecal droppings were collected from a variety of habitats. Collections were made without regard to the condition or age of the droppings. Individual droppings were picked off surfaces with a sterile cotton-tipped swab and transferred to an enrichment tube containing 10 ml tetrathionate broth and macerated. Subsequent analysis for Salmonella was conducted in the same manner described for the gecko gut.

All isolated identified as Salmonella await further testing to determine the specific serotype.

Sampling Sites

Geckos were collected from 13 sites and droppings were collected from 17 sites on the Island of Hawaii. The sampling sites encompassed a variety of structures ranging from classroom buildings, restaurants, dwellings and coconut trees. An attempt was made to cover as wide a geographical range as possible. Most sampling locations were at altitudes ranging from sea level to about 500 feet. Higher elevations had far fewer geckos.

Results and Discussion

Our results show Salmonella-infected geckos to be distributed throughout the island of Hawaii. Of 13 sites surveyed, 10 yielded geckos with Salmonella - a 76.9 percent occurrence (Table 1). The only sites not yielding Salmonella were Hapuna Beach Park on the leeward side of the island and Mooheau Park in Hilo. Hilo Shopping Center yielded only a single gecko which tested negative. Hapuna Beach and Mooheau Park differed from other collecting sites in being located close to the seashore in areas of low permanent human population. Helm (1981) in his study of 7 urban subdivisions on Oahu found Salmonella-infected geckos at all of the sampling sites. It may be that the incidence of Salmonella in geckos is correlated with human population density or activities. However, Kournay and Telford (1981) found Salmonella-infected reptiles in remote uninhabited forest areas as well as in urban areas in Panama; they suggest that reptile-salmonellae associations may be independent of human activities.

The incidence of Salmonella-infected geckos varied from site to site on the island of Hawaii. The incidences ranged from 0 to 22.2 percent occurrence. The highest levels of positive Salmonella isolations were made from geckos at Kawaihae Harbor, Hawaii Community College and Pepeekeo. Kourany and Telford (1981) found the highest level of reptile infection to be attributed to greater contact with sources of infection such as animal and human excreta. In Hawaii the infection of geckos by Salmonella contaminated animal excreta is unlikely. However, insects such as cockroaches are well known as carriers for Salmonella (Bitter and Williams, 1949). The ingestion of cockroaches may account for the relatively high Salmonella incidence in some of the gecko samples. In a sample of 10 geckos captured at the University of Hawaii at Hilo campus, 4 had cockroaches in their stomachs.

The overall incidence of Salmonella on the Island of Hawaii was 18 of 151 specimens - 11.9 percent. Our findings indicate that Salmonella is widespread among the geckos of the Island of Hawaii. Helm (1981) showed even higher incidence of Salmonella in the geckos of Oahu. Of 70 geckos captured on Oahu, 32 were positive for Salmonella, a 45.7 percent incidence. The higher incidence of positive geckos on Oahu might be due to a greater opportunity to contact Salmonella sources.

In Panama, Salmonella was isolated from 131 of 447 (29.4 percent) reptiles examined by Kourany and Telford (1981). The results of our study and others suggest salmonellae-reptile association to be commonplace.

If reptiles are to serve as sources of human salmonellosis, infection via their excreta would be the most likely mode of transmission. Our examination of gecko droppings, however, showed only 4 of 224 (1.8 percent) droppings from 17 sites to be positive for Salmonella (Table 2). The incidence of droppings positive for Salmonella seems low when compared to the percentage of geckos infected. Helm (1981) found 7 of 23 (30.4 percent) gecko feces positive for Salmonella in 9 households on Oahu. These homes also had 27 of 63 geckos (42.9 percent) positive for Salmonella.

It appears that gecko lizards in Hawaii present a vast reservoir of Salmonella. Transmission of Salmonella to humans from geckos would most likely occur through contamination of foods and water by their feces. A comparison of data from the islands of Oahu and Hawaii show a higher incidence of Salmonella-infected geckos in highly urbanized Oahu. It may be that high densities of animals, humans, insects and geckos promote the interspecies transmission of Salmonella.

How geckos acquired their Salmonella microflora needs to be determined. It is suspected that insects--in particular, cockroaches--to be the major source of Salmonella for geckos.

ACKNOWLEDGEMENT

The authors wish to thank R. Jake Marley for assistance in capturing geckos and to the National Institute of Health for support through the Minority Biomedical Research Support Grant 2 S06 RR 08073-10A1

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TABLE 1. *Salmonella* in Geckos from Various Sites on the Island of Hawaii

Sampling Sites	Number of Geckos	*Salmonella* Positive	
		Number	Percent
UH Hilo[1]	28	3	10.7
Mooheau Park	7	0	0
Cafe "A"	8	1	12.5
Hilo Shopping Center	1	0	0
Hawaii Community College	9	2	22.2
Keaau[2]	17	2	11.8
Captain Cook	6	1	16.6
Honaunau	22	2	9.1
Hapuna Beach	10	0	0
Kawaihae	15	3	20.0
Kailua	14	2	14.3
Pepeekeo	5	1	20.0
Pahoa	9	1	11.1
	151	18	11.9

[1] Wentworth Hall and College Hall

[2] Keaau Police Station and Credit Union Building

TABLE 2. *Salmonella* Isolations from Gecko Feces, Island of Hawaii

Sampling Area	No. of Sites	Number of Fecal Droppings	Positive for Salmonella	
			Number	Percent
Hilo District	9	141	2	1.4
Hamakua District	2	14	0	0
Ka'u District	1	10	0	0
Kailua, Kona District	5	59	2	3.4
	17	224	4	4.8