

# SOME BACTERIAL ENTEROPATHOGENS IN WILDLIFE AND RACING PIGEONS FROM TRINIDAD

Authors: Adesiyun, Abiodun A., Seepersadsingh, Nadira, Inder, Lisa, and Caesar, Kenneth

Source: Journal of Wildlife Diseases, 34(1): 73-80

Published By: Wildlife Disease Association

URL: https://doi.org/10.7589/0090-3558-34.1.73

The BioOne Digital Library (<u>https://bioone.org/</u>) provides worldwide distribution for more than 580 journals and eBooks from BioOne's community of over 150 nonprofit societies, research institutions, and university presses in the biological, ecological, and environmental sciences. The BioOne Digital Library encompasses the flagship aggregation BioOne Complete (<u>https://bioone.org/subscribe</u>), the BioOne Complete Archive (<u>https://bioone.org/archive</u>), and the BioOne eBooks program offerings ESA eBook Collection (<u>https://bioone.org/esa-ebooks</u>) and CSIRO Publishing BioSelect Collection (<u>https://bioone.org/csiro-ebooks</u>).

Your use of this PDF, the BioOne Digital Library, and all posted and associated content indicates your acceptance of BioOne's Terms of Use, available at <u>www.bioone.org/terms-of-use</u>.

Usage of BioOne Digital Library content is strictly limited to personal, educational, and non-commercial use. Commercial inquiries or rights and permissions requests should be directed to the individual publisher as copyright holder.

BioOne is an innovative nonprofit that sees sustainable scholarly publishing as an inherently collaborative enterprise connecting authors, nonprofit publishers, academic institutions, research libraries, and research funders in the common goal of maximizing access to critical research.

# SOME BACTERIAL ENTEROPATHOGENS IN WILDLIFE AND RACING PIGEONS FROM TRINIDAD

Abiodun A. Adesiyun,<sup>1</sup> Nadira Seepersadsingh,<sup>1</sup> Lisa Inder,<sup>2</sup> and Kenneth Caesar<sup>3</sup>

<sup>1</sup> School of Veterinary Medicine, Faculty of Medical Sciences, University of the West Indies, St. Augustine, Trinidad

<sup>2</sup> Faculty of Engineering, University of the West Indies, St. Augustine, Trinidad

<sup>3</sup> Emperor Valley Zoo, Port of Spain, Trinidad

ABSTRACT: Fecal and cloacal swabs or feces of wild mammalian, avian and reptilian species, either farmed or free-ranging, and of racing pigeons (*Columba livia*) kept in lofts were cultured for Salmonella spp., Campylobacter spp., and Yersinia spp. Of 291 free-ranging mammals tested, 6 (2%) and 1 (<1%) yielded positive cultures of Salmonella spp. and Campylobacter spp., respectively. Salmonella newport was the predominant serotype isolated and the opossum (Didelphis marsupialis insularis) had the significantly highest prevalence (29%) of Salmonella spp. infection compared to other species such as deer (Mazama americana trinitatis), lappe (Agouti paca), tattoo (Dasypus novemcinctus), agouti (Dasyprocta leporina), and wild hog (Tayassu tajacu). Among 14 species of farmed wildlife studied, 13 (7%) and 10 (5%) of 184 fecal or cloacal samples tested were positive for Salmonella spp. and Campylobacter spp., respectively. Salmonella javiana ac-counted for 50% of the Salmonella spp. isolates and C. jejuni represented 90% of the Campy-lobacter spp. cultured. Only 1 (1%) of 124 cloacal swabs of free-flying avian species yielded Salmonella spp. compared to 21 (17%) samples positive for Campylobacter spp. Of 171 racing pigeons which originated from 8 fanciers, 8 (5%) yielded Salmonella spp. all of which were serotype typhimurium while only 1 (1%) was positive for Campylobacter spp. Seven (88%) of 8 Salmonella spp. isolates were recovered from one fancier. Yersinia spp. was not cultured from any of the above samples. Although the prevalences of Salmonella spp. and Campylobacter spp. in wildlife in Trinidad are low, the practice of wildlife farming and the increased consumption of meat from wildlife may increase the health risk to human consumers.

Key words: Bacterial enteropathogens, Campylobacter spp., mammals, racing pigeons, Salmonella spp., survey, wild birds, Yersinia spp., zoonoses.

# INTRODUCTION

Free-ranging or captive wildlife species are asymptomatic carriers of enteric pathogens such as Salmonella spp., Campylobacter spp., and Yersinia spp. (Kapperud and Rosef, 1983; Fukata et al., 1986; Euden, 1990; Aguirre et al., 1991). Mortalities in various species also have been attributed to these enteric zoonoses (Shima and Osborn, 1984; Blake et al., 1991; Jacobson et al., 1992). The potential for free-ranging avian or mammalian species to contaminate the environment, particularly waterways, with waterborne zoonoses is well known (Kapperud, 1977; Mentzing, 1981; Kapperud and Rosef, 1983). The consumption of improperly cooked meat from these hosts also may lead to gastroenteritis in consumers (Prescott and Monroe, 1982; Ho et al., 1986; Anonymous, 1988; Oboegbulem and Okoronkwo, 1990).

There is a dearth of information on the prevalence of enteric zoonoses in the wild-

life population of Trinidad. Everard et al. (1979) is the only report documenting the isolation of Salmonella spp. from free-living host species in Trinidad and Grenada. However, since that study, the government of Trinidad and Tobago has embarked on a policy to encourage wildlife farming. The potential health risk to such farmers presently is unknown. Secondly, pigeon racing is becoming a popular sport on the island, with pigeons (Columba livia) flying between islands in the region. The prevalence of enteropathogens in these pigeons is unknown. Finally, during the annual hunting season from October to February, licensed hunters are allowed to kill wildlife for their consumption or sale to the population at certain outlets. It is well documented that during evisceration under poor sanitary practices, enteric pathogens may contaminate carcasses (Grizmek, 1979; Grau, 1988; Oboegbulem and Okoronkwo, 1990; Adesiyun and Krishnan,

1995). Enteric pathogens such as Salmonella spp., Campylobacter spp., and Yersinia spp. have been isolated in Trinidad from domestic livestock on farms (Adesiyun and Kaminjolo, 1994), slaughtered pigs (Adesiyun and Krishnan, 1995), and from market meat (Adesiyun, 1993). Therefore, this study was designed to determine the prevalence of important enteric zoonoses (salmonellosis, campylobacteriosis, and yersiniosis), in free-living and captive wildlife and in racing pigeons from Trinidad.

# MATERIALS AND METHODS

Free-ranging bird and mammal samples were collected from licensed hunters during the 1995–96 hunting season (1 October 1995 to 29 February 1996) in the island nation of Trinidad (10°30'N, 61°30'W). Groups of hunters across the country were contacted, prior to the opening of the hunting season, and their support solicited. Samples from captive wildlife species were obtained from individual farmers across the country registered with the Wildlife Section of the Ministry of Food Production (Marine Exploitation, Forestry and Environment, St. Joseph, Trinidad). Free-flying small avian species were trapped in forest areas and near a liquid sewage dump site using mist nets. Samples from vultures (Coragyps atratus) were obtained from a solid waste dump site. Samples from free-flying pigeons were collected from a flour mill (Port of Spain, Trinidad). Racing pigeons were sampled from the lofts of eight fanciers in Diego Martin, San Juan and Valsayn areas of Trinidad.

For wildlife species that were hunted, the hunters were requested to tie up a 5 cm section of the small intestine of the respective specimen during evisceration and to put the sample into sterile plastic bags that were provided. Information on the type of wildlife, location of the hunt and whether the animals were adults or a young specimen were indicated on the bags. Samples were kept at 4 C and sent to the laboratory as soon as possible. When the hunting group was in the field for a day or a weekend, they were provided with sterile swabs and tubes containing 9 ml of Amies transport medium (ATM) (Difco, Detroit, Michigan, USA) to collect swab samples of the intestinal contents. When intestinal contents could not be sent to the laboratory within 1 day following collection, they were stored frozen at -20 C.

Fecal samples were obtained from captive or farmed animals after restraint. Where it was

impossible to collect fecal samples, rectal swabs or cloacal swabs were obtained and transported to the laboratory in ATM. On a few occasions, freshly voided feces were collected with a clean wooden spatula, sampling only materials that had not made any contact with the floor or other surface.

To collect samples of small avian species, mist nets were set at selected sites. Fecal swabs or cloacal swabs were immediately obtained from trapped birds and dipped into ATM. The species of the birds were identified and immediately released. Occasionally, when many birds were trapped simultaneously, some were put into well-ventilated cardboard boxes, the cloacal swab samples were collected as soon as possible, and the birds subsequently were released.

Cloacal swabs or fecal samples were collected from feral pigeons at the rooftop of a flour mill in Port of Spain. The pigeons were enticed with grain into a wire-gauzed enclosure. Swabs of freshly voided feces of pigeons or their cloacal swab samples were obtained and dipped into ATM. The pigeons were released immediately.

At a solid waste dump, vultures were captured with the aid of a nylon string and their cloacal swab samples collected and put into ATM. The vultures were immediately released after sampling.

Crane (*Ardea cocoi*) and duck (*Dendrocygna bicolor*) samples were obtained from frozen intestinal contents provided by hunters. In the laboratory, the samples were thawed to obtain material for processing.

Finally, eight fanciers associated with pigeon racing participated in the study. Representative pigeons from each loft were sampled by collecting cloacal swabs or freshly voided feces and subsequently transported to the laboratory in ATM.

To culture for Salmonella spp., approximately 1 g of feces, rectal or cloacal swab samples was pre-enriched in 9 ml of selenite broth (Difco) at 42 C overnight. Thereafter, 1 ml each of inoculated selenite broth sample was enriched in 10 ml of tetrathionate broth (Difco) and 10 ml selenite cystine broth (Difco) and incubated at 37 C. Colonies on xylose lysine desoxycholate (XLD) agar (Difco) with black centers were inoculated into biochemical media using standard methods (Macfaddin, 1980; Food and Agricultural Organization, 1992). Polyvalent antisera A-I ∝ Vi for Salmonella spp. were used to identify all isolates biochemically identified as Salmonella spp. The confirmation and complete serological typing of the Salmonella spp. isolates were kindly done at the Caribbean Epidemiology Centre (Port of Spain, Trinidad), us-

Common name	Scientific name	Number tested	Number (%) of animals positive <sup>a</sup>	
			Salmonella spp.	Campylobacter spp.
Agouti	Dasyprocta leporina	232	1 (<1)	0 (0)
Opossum	Didelthis marsupialis insularis	17	5 (29)	1 (6) <sup>b</sup>
Deer	Mazama americana trinitatis	15	0 (0)	0 (0)
Lappe	Agouti paca	15	0 (0)	0 (0)
Armadillo	Dasypus novemcinctus	6	0(0)	0 (0)
Wild hog	Tayassu tajacu	6	0 (0)	0 (0)
Total		291	6 (2) <sup>c</sup>	1 (<1)

TABLE 1. Prevalence of Salmonella spp. and Campylobacter spp. in free-ranging mammals from Trinidad.

<sup>a</sup> All samples were negative for Yersinia spp.

<sup>b</sup> C. jejuni.

<sup>c</sup> 11 strains of the genus Salmonella consisting of serotypes S. newport (4), S. chameleon (2), S. albany (1) and S. oranienburg (4).

ing standard methods (Food and Agricultural Organization, 1992) and specific somatic (O) and flagella (H) antisera.

To isolate Campylobacter spp. swabs of feces, cloaca or rectums were inoculated onto bloodfree Campylobacter sp. agar containing CCDA supplement (Oxoid, Basingstoke, U.K.) and streaked for isolation. Inoculated plates were incubated at 42 C in a CO2 incubator (Forma Scientific Inc., Marietta, Ohio, USA) with 8 to 10%  $CO_2$  for 24 to 48 hr. Greyish, running colonies were Gram-stained and all Gram-negative, slender, comma-shaped, curved or sea gull-appearing isolates subcultured onto sheep blood agar and incubated at 42 C overnight in 8 to 10% CO2. Biochemical identification of isolates was done as described by Lior (1984). Hippurate hydrolysis (Lior, 1984) was used to distinguish between C. jejuni and C. coli.

To culture for Yersinia spp. in samples, 0.5 g of feces or swab samples were enriched in 4.5 ml of 0.067 M phosphate buffered saline (PBS) at pH 7.6 for 3 wk at 4 C. Subcultures were made after 1 wk and 3 wk of enrichment onto Yersinia spp. agar with selective supplement (Oxoid) and streaked for isolation. Inoculated plates were incubated at room temperature for 24 to 48 hr. Typical "bull-eye"-appearing colo-nies were Gram-stained and the isolates that were Gram-negative coccobacilli were subjected to biochemical tests which included inoculation into triple sugar iron (TSI) agar, urea agar, sulphide iron motility (SIM) agar, methylred broth, Voges-Proskauer broth and testing for oxidase activity and motility. All tests, with the exception of oxidase activity detection, were done at 25 and 37 C. Identification procedures used were those suggested by Schiemann and Fleming (1981).

Statistical comparisons across prevalence in

the pipes utilized chi-squared analyses (Cotton, 1994). Significance was established at  $P \leq 0.05$ .

# RESULTS

The results of isolation attempts for agents of salmonellosis, campylobacteriosis, and versiniosis from free-ranging mammals are presented in Table 1. Of the 291 fecal or rectal swab samples processed, 6 (2%) and 1 (<1%) were positive for Salmonella spp. and Campylobacter spp., respectively. The prevalence of Salmonella spp. in opossums (Didelphis marsupialis insularis) (29%) was significantly  $(P \le 0.001; \chi^2$ -analysis) higher than for the other 5 infected species including lappe (Agouti paca), deer (Mazama americana trinitatis), agouti (Dasyprocta leporina), tattoo (Dasypus novemcinctus) and wild hog (Tayassu tajacu). The predominant serotype of the genus Salmonella was newport accounting for 4 (36%) of 11 isolates. The only Campylobacter spp. isolate was C. jejuni collected from an opossum. All tested samples were negative for Yersinia spp.

Table 2 shows the prevalence of agents for salmonellosis and campylobacteriosis in farmed wildlife. Of a total of 14 host species tested, 13 (7%) and 10 (5%) of 184 fecal or cloacal samples cultured yielded *Salmonella* spp. and *Campylobacter* spp., respectively. *Salmonella* spp. infection ranged from 0% to 50% (turtles), but the

#### 76 JOURNAL OF WILDLIFE DISEASES, VOL. 34, NO. 1, JANUARY 1998

Common names	Scientific names	Number tested	Number (%) of animals positive <sup>4</sup> for:	
			Salmonella spp.	Campylobacter spp.
Agouti	Dasyprocta leporina	88	2 (2)	8 (9) <sup>b</sup>
Snake <sup>c</sup>	Amphisbaena alba	23	4 (17)	0(0)
Deer	Mazama americana trinitatis	19	0(0)	0(0)
Lappe	Agouti paca	10	2(20)	0(0)
Monkey	Alouata seniculus	9	1(11)	0(0)
Pigeon	Columba spp.	8	0(0)	0(0)
Parrot	Amazona amazonica	6	0(0)	0(0)
Wild hog	Tayassu tajacu	5	2 (40)	1 (20) <sup>e</sup>
Porcupine	Coendou prehensilis	5	0 (0.0)	$1 (20)^{b}$
Marocov	Geochelone denticulata	4	0 (0.0)	0(0)
Turtle	Chelydra serpentina	4	2 (50)	0(0)
Toucan	Ramphastos tucanas	-1	0(0)	0(0)
Macaw	Ara macao	1	0(0)	0(0)
Caiman	Caiman crocodilus	1	0(0)	0(0)
Total		184	$13 \ (7)^{d}$	10 (5)

TABLE 2. Prevalence of enteropathogens in farmed wildlife from Trinidad.

<sup>a</sup> All samples were negative for Yersinia spp.

<sup>b</sup> C. jejuni.

<sup>c</sup> Others are: Macajuel (*Boa constrictor*), Tigre (*Spilotes pullatus*), Horsewhip snake (*Oxybelis acneus*), Red-spitting cobra (*Naja pallida*) and South American rattlesnake (*Crotalus durissus*).

<sup>d</sup> C. coli.

<sup>c</sup> A total of 16 strains of the genus Salmonella were isolated consisting of serotypes S. javiana (S), S. gaminara (3), S. typhimurium (2), S. nigeria (1), S. parera (1) and S. oranienburg (1).

difference was not statistically significant ( $P \ge 0.05$ ;  $\chi^2$ -analysis). Salmonella spp. serotype javiana accounted for 50% of all Salmonella spp. isolates. Six (43%) of 14 host species yielded Salmonella spp. isolates. Agoutis yielded 8 (80%) of the 10 Campylobacter isolates. Nine (90%) of the 10 Campylobacter spp. were C. jejuni. Only 3 (21%) of 14 animal hosts yielded Campylobacter spp.; these included the agouti, porcupine (Coendou prehensils) and wild hog.

A comparison of free-ranging (Table 1) and captive (Table 2) agouti, deer, lappe and wild hog showed significant differences in prevalences of *Salmonella* spp. and *Campylobacter* spp. Of 268 samples of free-ranging agouti (n = 232), deer (n = 15), lappe (n = 5) and wild hog (n = 6), only 1 (<1%) agouti was positive for *Salmonella* spp. compared to a prevalence of 5% (6 of 132) found in farmed agouti (n = 88), deer (n = 19), lappe (n = 20) and wild hog (n = 5). The difference was statistically significant ( $P \le 0.01$ ;  $\chi^2$ -analysis). Similarly, the prevalences of *Campylobacter* spp. in free-ranging wildlife, 0% (0 of 268) was statistically significantly lower ( $P \le 0.001$ ;  $\chi^2$ -analysis) than the 7% (9 of 132) found for captive (farmed) wildlife species.

Of 124 cloacal swabs of free-ranging birds that were cultured, 1 (<1%) and 21 (17%) were positive for *Salmonella* spp. and *Campylobacter* spp., respectively (Table 3). The difference in prevalences of *Salmonella* spp. and *Campylobacter* spp. was statistically significant ( $P \le 0.001$ ;  $\chi^2$ -analysis). One vulture yielded the only *Salmonella* spp. (serotype Group B) isolate while all 21 isolates of *C. jejuni* originated from pigeons in the limits of Port of Spain. The prevalence (36%) was statistically significantly ( $P \le 0.001$ ;  $\chi^2$ -analysis) higher than the 0% found in other avian species.

Table 4 shows the prevalence of Salmonella spp. and Campylobacter spp. in racing pigeons. Of 171 pigeons originating

		Number (%) positive	
Species	Number tested	Salmon- ella	Campylo- bacter
Free-flying birds <sup>b</sup>	60	0 (0)	0 (0)
Free-flying pigeons <sup>e</sup> (Columba livia)	59	0 (0)	21 (36) <sup>e</sup>
Vulture (Coaragyps atratus)	3	1 (33) <sup>d</sup>	0(0)
Crane (Ardea cocoi)	1	0 (0)	0 (0)
Duck (Dendrocygna bicolor)	1	0 (0)	0 (0)
Total	124	1(1)	21 (17)

TABLE 3. Prevalence of enteropathogens from free-<br/>flying birds in Trinidad.

TABLE 4. Prevalence of enteropathogens in racingpigeons from Trinidad.

\* All samples were negative for Yersinia spp.

<sup>b</sup> Consisted predominantly of 15 Tanagers (*Ramphacelus carbo*), 14 Doves (*Geopelia cuneata* and *Streptopelia decaoeto*),
8 Yellow-hooded blackbird (*Agelaius icterocephalus*), 5 Thrush (*Turdus nudigenis*) and 3 Banaquit (*Coereba flaveola*).

<sup>c</sup> Pigeons around a flour mill located in Port of Spain.

<sup>d</sup> Salmonella sp. Group B.

<sup>c</sup> All isolates were *C. jejuni*.

from 8 fanciers, 8 (5%) were positive for Salmonella spp. compared to only 1 (<1%) positive that was for Campylobacter spp. The difference was statistically significant ( $P \leq 0.05$ ;  $\chi^2$ -analysis). All 14 strains of Salmonella spp. isolated were of serotype typhimurium. Pigeons from lofts in fancier II yielded 7 (88%) of the 8 isolates of Salmonella spp. while pigeons from the lofts of 6 fanciers were negative for the microorganism.

*Yersinia* spp. was not isolated from the processed samples of any of the sources (Tables 1–4).

### DISCUSSION

Meat originating from mammalian, avian and reptilian species is a rapidly growing delicacy among consumers in Trinidad and Tobago. Thus, it is imperative to assess its potential health risk. Meatborne epidemics of salmonellosis, campylobacteriosis and yersiniosis are well documented (Checko et al., 1977; Prescott and Monroe, 1982; Centers for Disease Control, 1990).

Although the prevalence of *Salmonella* spp. infection found in free-living mam-

Baging		Number (%) positive <sup>a</sup>		
fancier loft	Number sampled	Salmonella spp.	Campylobacter spp.	
I	28	0 (0)	0 (0)	
II	28	7 (25)	0(0)	
III	19	0(0)	0(0)	
IV	21	0(0)	1 (5)	
V	29	0(0)	0(0)	
VI	16	0(0)	0(0)	
VII	11	0(0)	0(0)	
VIII	19	1 (5)	0 (0)	
Total	171	8 (5) <sup>b</sup>	1 (1) <sup>c</sup>	

<sup>a</sup> All samples were negative for Yersinia spp.

<sup>b</sup> Fourteen strains of *Salmonella typhimurium* were isolated. <sup>c</sup> C. jejuni.

mals in the present study is relatively low (2%), the finding agrees with published reports (Taylor, 1969; Everard et al., 1979; Howerth et al., 1994). However, it is difficult to ignore the health risk these wildlife meats may pose to the consumer because opossum, a popular delicacy, had a significantly higher prevalence of Salmonella spp. infection (29%) compared to other wild mammals. Because the opossum is a carrion-eating animal, it may have a higher exposure potential to Salmonella spp. compared to herbivorous species. Similar prevalences of Salmonella spp. infection in the opossum are reported and these range from 12 to 20% (Kourany et al., 1976; Everard et al., 1979). Badgers (Meles meles) which have similar feeding habits to those of opossums were found to be more frequently infected with Salmonella spp. than other wildlife in the same environment in the United Kingdom (Euden, 1990).

Of epidemiological significance was the comparison of species of free-ranging with farmed mammals which indicated that the prevalence of *Salmonella* spp. in captive species was significantly higher. Confinement, diet, and closeness to humans are some factors that may be responsible for this difference. It also was of interest that the predominant serotypes of the genus Salmonella isolated from free-living and captive hosts were different, an indication of different sources of exposure. However, it is of zoonotic relevance from the view point that a majority of the serotypes of the genus Salmonella from both sources have been isolated from human gastroenteritis cases in Trinidad (Caribbean Epidemiology Centre, 1983-90). Also, a number of these serotypes have been isolated from domestic livestock in this environment (Adesiyun et al., 1993). Contamination of carcasses and improper cooking of meat and meat products have been known to cause gastroenteritis in consumers (Grizmek, 1979; Ho et al., 1986; Oboegbulem and Okoronkwo, 1990; Adesiyun and Krishnan, 1995).

The relatively higher prevalences of Salmonella spp. in apparently healthy snakes (17%) and turtles (50%) were not unexpected as similarly high prevalences have been reported in other studies (Harvey and Price, 1983; MacNeill and Dorward, 1986; Zwart, 1986). Reptiles are known to have asymptomatic infections of salmonellae (Zwart, 1986; Obwolo and Zwart, 1993).

The prevalence of Salmonella spp. infections in avian hosts was generally low with the isolations made only from a vulture and from semi-captive racing pigeons. Salmonella spp. in apparently healthy birds have been reported to be low (Locke et al., 1973; Kapperud and Rosef, 1983; Brittingham et al., 1988). However, it is well documented that the feeding habits of birds affect the prevalence of infection by Salmonella spp. Omnivorous seagulls (Larus atricilla) are known to be more frequently infected than herbivorous avian species such as pigeons (Kapperud and Rosef, 1983; Quessy and Messier, 1992). Seagulls, because of their feeding habits, have been associated with occurrences of human and animal salmonellosis (Reilly et al., 1981; Williams et al., 1977). The comparatively higher prevalence of Salmonella spp. infection in racing pigeons from one fancier could be attributed to poor management practices. Finally vultures, because of their carrion-eating practices, have been reported to be asymptomatic carriers of several enteric pathogens including *Salmonella* spp. (Houston and Cooper, 1975).

Campylobacter spp. prevalence in freeliving or captive mammals, while generally low, had higher prevalences in farmed species; this may reflect the feed and contact with human handlers. Comparatively lower prevalences of C. jejuni have been found elsewhere, as well as a predominance of C. jejuni over C. coli in infected animals (Skirrow and Benjamin, 1980). However, birds are known to be important reservoirs of Campylobacter spp. while they only act as sporadic carriers of Salmonella spp. and Yersinia spp. (Kapperud and Rosef, 1983). Variations in the diet of the respective species, as well as whether they feed in forested or urban areas, may significantly affect the prevalence of C. jejuni (Kapperud and Rosef, 1983; Quessy and Messier, 1992). Water borne campylobacteriosis in humans has been associated with avian contamination (Mentzing, 1981). Our findings that pigeons sampled in Port of Spain had a higher prevalence of C. jejuni infection may be attributed to their exposure in an urban setting as previously reported by Kapperud and Rosef (1983) and Fukata et al. (1986).

The fact that Yersinia spp. was not isolated from all the potential host species studied was not unexpected because in tropical environments like Trinidad and Tobago, yersiniosis in domestic livestock was found to be very low (Adesiyun and Kaminjolo, 1994). Pigs, which are natural reservoirs of Yersinia spp., had a prevalence of 2% (6 of 296), cattle had <1% (1 of 30) and all the sheep tested were negative for the infection (Adesiyun and Kaminjolo, 1994). Similarly in temperate countries, prevalence of versiniosis in wildlife is generally low. Kapperud and Rosef (1983) reported that only 1% of 504 wild birds in Norway were positive. Kwaga and Iversen (1993) found only 1 of 201 snakes in Canada was infected with *Yersinia* spp.

While it is evident from our study that the prevalences of *Salmonella* spp. and *Campylobacter* spp. in wildlife from Trinidad are relatively low, their potential to contaminate the environment cannot be ignored. The practice of wildlife farming and the increased consumption of meat from wildlife may enhance the health risk to human consumers.

## ACKNOWLEDGMENTS

The Pan American Health Organization is thanked for funding this project. The assistance of N. Dipta of the Emperor Valley Zoo in trapping avian wildlife with mist nets is acknowledged. We are grateful to the staff of the wildlife section of the Ministry of Food Production, Marine Exploitation, Forestry and Environment for assisting in sampling captive wildlife at various farms. Hunters in many groups across Trinidad who provided valuable samples are acknowledged for their cooperation. The technical services provided by G. Ramirez is appreciated. We thank L. John for typing the manuscript.

# LITERATURE CITED

- ADESIYUN, A. A. 1993. Prevalence of Listeria spp., Campylobacter spp., Salmonella spp., Yersinia spp. and toxigenic Escherichia coli on meat and seafood in Trinidad. Food Microbiology 10: 395– 403.
- ——, AND J. S. KAMINJOLO. 1994. Prevalence and epidemiology of selected enteric infections in livestock in Trinidad. Preventive Veterinary Medicine 19: 151–165.
- —, —, R. LOREGNARD, AND W. KITSON-PIGGOT. 1993. Epidemiology of *Salmonella* infections in Trinidadian livestock. Revue d'Elevage et de Medecine Veterinaire des Pays Tropicaux 46: 435–437.
- , AND C. KRISHNAN. 1995. Occurrence of Yersinia enterocolitica 0:3, Listeria monocytogenes and thermophilic Campylobacter spp. in slaughter pigs and carcasses in Trinidad. Food Microbiology 12: 99–107.
- AGUIRRE, A. A., R. S. COOK, R. G. MCLEAN, T. J. QUAN, AND T. R. SPRAKER. 1991. Occurrence of potential pathogens in wild Caribbean flamingos (*Phoenicopterus ruber ruber*) during a lead poisoning die off in Yucatan, Mexico. Journal of Zoo and Wildlife Medicine 22: 470–475.
- ANONYMOUS. 1988. Thryonomys swinderianus (the cane rat). In the New Encyclopedia Britannica,

15th ed., Vol. 2. Encyclopedia Britannica Inc., Chicago, Illinois, 2036p.

- BLAKE, J. E., B. D. MCCLEAN, AND A. GUNN. 1991. Yersiniosis in free-ranging muskoxen on Banks Island, Northwest Territories, Canada. Journal of Wildlife Diseases 27: 527–533.
- BRITTINGHAM, M. C., S. A. TEMPLE, AND R. M. DUNCAN. 1988. A survey of the prevalence of selected bacteria in wild birds. Journal of Wildlife Diseases 24: 299–307.
- CARIBBEAN EPIDEMIOLOGY CENTRE. Surveillance Report. 1983. CAREC, Port of Spain, Trinidad, 56 pp.
- ——. 1984. CAREC, Port of Spain, Trinidad, 70 pp.
- ——. 1985. CAREC, Port of Spain, Trinidad, 92 pp.
- . 1986. CAREC, Port of Spain, Trinidad, 77 pp.
- ——. 1987. CAREC, Port of Spain, Trinidad, 79 pp.
- ——. 1988. CAREC, Port of Spain, Trinidad, 82 pp.
- -------. 1989. CAREC, Port of Spain, Trinidad, 96 pp.
- ------. 1990. CAREC, Port of Spain, Trinidad, 117 pp.
- CENTERS FOR DISEASE CONTROL. 1990. Yersinia enterocolitica infections during holidays in black families-Georgia. Morbidity and Mortality Weekly Reports 39: 819–821.
- CHECKO, P. J., J. N. LEWIS, R. ALTMAN, G. HALPIN, R. M. INGLIS, R. M. PIERCE, M. K. PILOT, J. PRINCE, R. RANDOR, M. FLEISSNER, D. O. LY-MAN, AND W. E. PARKIN. 1977. Multi-state outbreak of Salmonella newport transmitted by precooked roast beef. Morbidity and Mortality Weekly Reports 26: 277–278.
- COTTON, T. 1994. Statistics in medicine. Little, Brown and Company, Boston, Massachusetts, 372 pp.
- EUDEN, P. R. 1990. Salmonella isolates from wild animals in Cornwall. British Veterinary Journal 146: 228–232.
- EVERARD, C. O. R., B. TOTA, D. BASSETT, AND C. ALI. 1979. Salmonella in wildlife from Trinidad and Grenada, W.I. Journal of Wildlife Diseases 15: 213–219.
- FOOD AND AGRICULTURAL ORGANIZATION. 1992. Manual of Food Quality Control 4, Review 1. Microbiological Analysis. FAO, Rome, Italy, 338 pp.
- FUKATA, T., T. UEMURA, E. BABA, S. HORIUCHI, AND A. ARAKAWA. 1986. Isolation of clostridia, salmonellae and coccidia from wild pigeons in Japan. British Veterinary Journal 142: 291–293.
- GRAU, F. H. 1988. Campylobacter jejuni and C. hyointestinalis in the intestinal tract and on the carcasses of calves and cattle. Journal of Food Protection 51: 857–861.

#### 80 JOURNAL OF WILDLIFE DISEASES, VOL. 34, NO. 1, JANUARY 1998

- GRIZMEK, B. 1979. The African cane rat (*Thryono-mys swinderianus*). In Animal life encyclopedia, Vol. II. Reinhold Company, New York, New York, 627 pp.
- HARVEY, R. W. S., AND T. H. PRICE. 1983. Salmonella isolation from reptilian faeces: A discussion of appropriate cultural techniques. Journal of Hygiene, Cambridge 91: 25–31.
- HO, J. O., K. J. SHANDS, G. FOREDLAND, P. ECKIND, AND D. W. FRASER. 1986. An outbreak of type 4b Listeria monocytogenes infection involving patients from eight Boston hospitals. Archives of Internal Medicine 146: 520–524.
- HOUSTON, D., AND J. COOPER. 1975. The digestive tract of the Whiteback griffon vulture and its role in disease transmission among wild ungulates. Journal of Wildlife Diseases II: 306–313.
- HOWERTH, E. W., A. J. REEVES, M. R. MCELVEEN, AND F. W. AUSTIN. 1994. Survey for selected diseases in Nutria (*Mycoastor coypus*) from Louisiana. Journal of Wildlife Diseases 30: 450–453.
- JACOBSON, E. R., J. M. GASKIN, S. WELLS, K. BOW-LER, AND J. SCHUMACHER. 1992. Epizootic of ophidian paramyxovirus in a zoological collection: Pathological, microbiological, and serological findings. Journal of Zoo and Wildlife Medicine 23: 318–327.
- KAPPERUD, G. 1977. Yersinia enterocolitica and Yersinia-like microbes isolated from mammals and water in Norway and Denmark. Acta Pathology and Microbiology, Scandinavian Section B 85: 129–135.
  - —, KAPPERUD, G., AND O. ROSEF. 1983. Avian wildlife reservoir of *Campylobacter fetus* subsp. *jejuni*, *Yersinia* spp. and *Salmonella* spp. in Norway. Applied and Environmental Microbiology 45: 375–380.
- KOURANY, M., L. BOWDRE, AND A. HERPER. 1976. Panamanian forest mammals as carriers of Salmonella. American Journal of Tropical Medicine and Hygiene 25: 449–455.
- KWAGA, J., AND J. O. IVERSEN. 1993. Isolation of Yersinia enterocolitica (0:5,27 biotype 2) from a common Garter snake. Journal of Wildlife Diseases 29: 127–129.
- LIOR, H. 1984. New, extended biotyping scheme for Campylobacter jejuni, Campylobacter coli and Campylobacter laridis. Journal of Clinical Microbiology 20: 636–640.
- LOCKE, L. N., R. B. SHILLINGER, AND J. JAREED. 1973. Salmonellosis in passerine birds in Maryland and West Virginia. Journal of Wildlife Diseases 9: 144–145.

MACFADDIN, J. F. 1980. Biochemical tests for iden-

tification of medical bacteria. Williams & Wilkins, Baltimore, Maryland, 527 pp.

- MACNEILL, A. C., AND W. J. DORWARD. 1986. Salmonella prevalence in a captive population of herptiles. Journal of Zoo Animal Medicine 17: 110–114.
- MENTZING, L. O. 1981. Waterborne outbreak of *Campylobacter* enteritis in Central Sweden. Lancet ii: 352–354.
- OBOEGBULEM, S. I., AND I. OKORONKWO. 1990. Salmonellae in the African Great Cane Rat (*Thryonomys swinderianus*). Journal of Wildlife Diseases 26: 119–121.
- OBWOLO, M. J., AND P. ZWART. 1993. Prevalence of Salmonella in the intestinal tracts of farm-reared crocodiles (Crocodylus niloticus) in Zimbabwe. Journal of Zoo and Wildlife Medicine 24: 175– 176.
- PRESCOTT, J. F., AND D. L. MONROE. 1982. Campylobacter enteritis in man and domestic animals. Journal of the American Veterinary Medical Association 181: 1524–1530.
- QUESSY, S., AND S. MESSIER. 1992. Prevalence of Salmonella spp., Campylobacter spp. and Listeria spp. in ring-billed gulls (Larus delawarensis). Journal of Wildlife Diseases 28: 526–531.
- REILLY, W. J., G. I. FORBES, G. M. PATERSON, AND J. C. M. SHARP. 1981. Human and animal salmonellosis in Scotland associated with environmental contamination, 1973–79. The Veterinary Record 108: 535–555.
- SCHIEMANN, D. A., AND C. A. FLEMING. 1981. Yersinia enterocolitica isolated from throats in swine in Eastern and Western Canada. Canadian Journal of Microbiology 27: 1326–1333.
- SHIMA, A. L., AND K. G. OSBORN. 1989. An epornitic of Salmonella typhimurium in a collection of lories and lorikeets. Journal of Zoo and Wildlife Medicine 20: 373–376.
- SKIRROW, M. B., AND J. BENJAMIN. 1986. "1001" campylobacters: Cultural characteristics of intestinal campylobacters from man and animals. Journal of Hygiene Cambridge 85: 427–442.
- TAYLOR, J. 1969. Salmonella in wild animals. In Diseases in free-living wild animals. A. McDiarmid, (ed.). Academic Press, London, England, pp. 53– 73.
- WILLIAMS, B. M., D. W. RICHARDS, D. P. STEPHENS, AND T. GRIFFITHS. 1977. The transmission of S. livingston to cattle by the herring gull (Larus argentatus). The Veterinary Record 100: 450–451.
- ZWART, P. 1986. Infectious diseases of reptiles. In Zoo and wild animal medicine, 2nd ed., M. E. Fowler (ed.). W. B. Saunders Co.. Philadelphia, Pennsylvania, pp. 1957–1961.

Received for publication 2 January 1997.