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# *Salmonella arizonae* in the United Kingdom from 1966 to 1990

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SUMMARY

*Salmonella arizonae* are rarely isolated in the UK. Since 1966 there have been sixty-six isolates from humans of whom 35% gave a recent history of foreign travel. Terrapins and snakes are potential sources of infection.

## INTRODUCTION

Bacteria of the Arizona group were first described by Caldwell and Ryerson [1]. The bacteria had been isolated from three different reptiles and were designated *Salmonella* sp. (Dar-es-salaam type, variety from Arizona), because like *Salmonella dar-es-salaam*, they liquefied gelatin.

Edwards, Fife and Ramsey [2] reported isolations of the Arizona group from reptiles, poultry and mammals including humans. For many years, there was disagreement regarding the classification of this group of bacteria. Edwards and Ewing [3] considered it a separate genus with its own antigenic scheme. Kauffmann [4] included it in the *Salmonella* genus as subgenus III, because of the biochemical reactions. Rohde [5] integrated all known arizona serotypes into the Kauffmann–White scheme, assigning the equivalent salmonella antigenic structure. Recent genetic and taxonomic studies have shown that all salmonellae and arizonae make up a single species which can be divided into six subspecies [6, 7]. Subspecies IIIa *Salmonella enterica* subspecies *arizonae* represent the former monophasic arizona serotypes. Subspecies IIIb *Salmonella enterica* subspecies *diarizonae* were the former diphasic arizona serotypes [8].

Because of the confused nomenclature the Division of Enteric Pathogens refers to bacteria of the former Arizona group as *Salmonella arizonae* as suggested by Kauffmann and Rohde [9].

This report describes the occurrence of *S. arizonae* in the UK during the period 1966–90. Isolations from animals in zoological collections are not included as they are of no importance in the epidemiology of human infections.

## MATERIALS AND METHODS

### *Bacterial strains*

Strains were referred to the Division of Enteric Pathogens (DEP) between January 1966 and December 1990, by laboratories of the Public Health

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Laboratory Service, hospital laboratories and laboratories of the Veterinary Investigation Service.

*Identification*

The strains were confirmed biochemically as *Salmonella* sp. using the methods of Cowan and Steel [10], subspecies determination was carried out using the methods of Kauffmann [11].

*Serotyping*

Serotyping was carried out using absorbed single factor antisera produced in the DEP according to the methods of Kauffmann [12]. When more detailed antigenic structure was indicated the methods of Edwards and Ewing [13] were used.

In the tables both the salmonella and arizona antigenic structures of the serotypes are listed. In the text serotypes are referred to by their salmonella antigenic structure (*Sa*).

*Testing for antimicrobial drug resistance*

All strains identified during the period 1978–90 were tested for resistance to the following antimicrobial drugs: ampicillin, chloramphenicol, kanamycin, sulphonamides, tetracyclines, trimethoprim, furazolidone, gentamicin and nalidixic acid. The methods used were those described by Anderson and Threlfall [14].

## RESULTS

*Human infections*

The first recorded human infection in the UK with *S. arizonae* was in 1966. This was due to serotype *Sa* 61 : c : $z_{35}$ isolated from a girl of 3 years who had gastroenteritis [15].

Sixty-six isolations belonging to 29 serotypes were identified during the period 1966–90; these results are presented in Table 1. Twenty-three patients (35%) gave a history of foreign travel. Two reported contact with terrapins, and snakes were the possible cause of 11 of the remainder.

A new serotype was isolated in 1974, with the antigenic structure *Sa* 60 : r : $z_{35}$. This was from a 40-year-old male who had been working in Nairobi, Kenya for several years, and had acquired his infection while on holiday on the coast of Kenya before returning to this country.

*Animal infections*

The isolation from animals are presented in Table 2. The serotype *Sa* 17 : $z_4$,$z_{32}$ : -, was isolated from turkey poults in 1968 [16].

There was one porcine and one canine isolation during this period. There were 4 isolations from tortoises and 25 from terrapins or terrapin tank water. Seven different serotypes were isolated from terrapins, *Sa* 61 : 1v : 1,5,7 being the most common serotype.

Forty-four isolations were made from sheep, 37 belonged to serotype

Table 1. *Human infections*

| Serotype | | Total | Travel abroad | Country visited |
|---|---|---|---|---|
| Salmonella antigens | Arizona antigens | | | |
| 6,14 : $z_{10}$ : z | 7a,7c : 27-31 | 1 | 1 | Greece |
| 17 : $z_{10}$ : e,n,x,$z_{15}$ | 12 : 27-28 | 2 | — | |
| 41 : $z_4$,$z_{23}$ : - | 13 : 1,2,5 : - | 3 | — | |
| 44 : $z_4$,$z_{23}$ : - | 13 : 1,2,6 : - | 1 | 1 | USA |
| 47 : k : e,n,x,$z_{15}$ | 28 : 29-28 | 1 | 1 | Zimbabwe |
| 47 : k : $z_{35}$ | 23 : 29-21 | 1 | — | |
| 47 : r : $z_{53}$ | 23 : 24-25 | 1 | — | |
| 48 : i : z | 5,29 : 33-31 | 4 | — | |
| 48 : i : $z_{35}$ | 5,29 : 33-21 | 1 | — | |
| 48 : k : z | 5,29 : 29-31 | 1 | — | |
| 48 : k : $z_{53}$ | 5,29 : 29-25 | 1 | — | |
| 48 : $z_4$,$z_{24}$ : - | 5 : 1,3,11 : - | 1 | — | |
| 48 : $z_{52}$ : z | 5 : 26-31 | 1 | — | |
| 50 : l,v : $z_{35}$ | 9 : 23-21 | 1 | — | |
| 50 : k : z | 9 : 29-31 | 1 | — | |
| 50 : $z_{52}$ : $z_{35}$ | 9 : 26-21 | 1 | — | |
| 51 : $z_4$,$z_{23}$ : - | 1,2 : 1,2,5 : - | 1 | — | |
| 53 : r : $z_{35}$ | 1,4 : 24-21 | 1 | — | |
| 60 : r : z | 24 : 24-31 | 2 | — | |
| 60 : r : $z_{35}$ (new type) | 24 : 24-21 | 1 | 1 | Kenya |
| 61 : c : $z_{35}$ | 26 : 32-21 | 8 | 5 | Greece 2, Mauritius 1, Egypt 1, Yugoslavia 1 |
| 61 : c : 1,5,7 | 26 : 32-30 | 1 | — | |
| 61 : i : $z_{53}$ | 26 : 33-25 | 2 | 2 | Middle East 1, France 1 |
| 61 : k : 1,5,7 | 26 : 29-30 | 2 | 1 | Cyprus |
| 61 : l,v : $z_{35}$ | 26 : 23-21 | 7 | 4 | Egypt 1, India 1, Zambia 1, Japan 1 |
| 61 : l,v : 1,5,7 | 26 : 23-30 | 13 | 5 | Spain 2, India 2, West Africa 1 |
| 61 : r : $z_{53}$ | 26 : 24-25 | 2 | 1 | Tanzania |
| 65 : (k) : $z_{53}$ | 30 : 22-25 | 1 | — | |
| 65 : $z_{52}$ : z | 30 : 26–31 | 1 | 1 | Australia |
| 0 = rough : $z_{10}$ : e,n,x,$z_{15}$ | 0 = rough : 27-25 | 1 | — | |
| 0 = rough : $z_{29}$ | 0 = rough : 16,17,18 | 1 | — | |
| Total | | 66 | 23 | |

*Sa* 61 : k : 1,5,7. The remaining seven were serotype *Sa* 61 : - : 1,5,7 probably a monophasic variant of *Sa* 61 : k : 1,5,7.

*Other sources*

The isolations from animal feed and human foods are given in Table 3. Seven serotypes were isolated from ingredients used in animal feed. Three of the products, kangaroo meat, horse meat, and crushed bone were imported, the remaining were: one from meat and bone meal, one from bone meal, one from dog food and one from oats. The isolations from dog food and oats were serotype *Sa* 61 : k : 1,5,7 which is the most common arizona serotype found in sheep. There were 12 isolations belonging to five serotypes from human foods. All the foods were imported and seven isolates were from Italian pasta.

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Table 2. *Isolations from animals*

| Serotype | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Salmonella antigens | Arizona antigens | Turkey | Porcine | Ovine | Canine | Tortoise | Terrapin | Pet snakes | Total |
| 17 : $z_{10}$e,n,x,$z_{15}$ | 12 : 27-28 | · | · | · | · | · | · | 1 | 1 |
| 18 : $z_4$,$z_{32}$ : - | 7a,7b : 1,7,8 : - | 20 | · | · | · | · | · | · | 20 |
| 42 : (k) : $z_{35}$ | 15 : 22-21 | · | · | · | · | · | 1 | · | 1 |
| 47 : r : $z_{53}$ | 23 : 24-25 | · | · | · | · | · | 1 | · | 1 |
| 50 : k : z | 9 : 29-31 | · | · | · | · | 1 | · | · | 1 |
| 50 : r : $z_{35}$ | 9 : 24-25 | · | · | · | · | 1 | · | · | 1 |
| 50 : - : - | 9 : - : - | · | · | · | · | 1 | · | · | 1 |
| 53 : $z_{52}$ : $z_{35}$ | 1,4 : 26-21 | · | · | · | · | · | 1 | · | 1 |
| 60 : r : e,n,x,$z_{15}$ | 24 : 24-28 | · | · | · | · | · | 4 | · | 4 |
| 60 : r : z | 24 : 24-31 | · | · | · | · | · | 2 | · | 2 |
| 61 : e : $z_{35}$ | 26 : 32-21 | · | · | · | · | 1 | 2 | · | 3 |
| 61 : l,v : 1,5,7 | 26 : 23-30 | · | · | · | · | · | 14 | 1 | 15 |
| 61 : k : 1,5,7 | 26 : 29-30 | · | 1 | 37 | 1 | · | · | · | 39 |
| 61 : - : 1,5,7 | 26 : - : 30 | · | · | 7 | · | · | · | · | 7 |
| Total | | 20 | 1 | 44 | 1 | 4 | 25 | 2 | 97 |

Table 3. *Other sources*

| Serotype | | | |
|---|---|---|---|
| Salmonella antigens | Arizona antigens | Animal feed | Human foods |
| 13,22:-:- | 18:-:- | | Gum tragacanth |
| 18:$z_4$,$z_{23}$:- | 7a,7b:1,2,6:- | | Italian pasta, x4 |
| 18:$z_4$,$z_{32}$:- | 7a,7b:1,7,8:- | | Italian pasta, x3, Polish egg albumin |
| 38:l,v:$z_{53}$ | 16:23-25 | Australian kangaroo meat | |
| 43:r:e,n,x,$z_{15}$ | 21:24-28 | Argentinian horse meat | |
| 48:i:z | 29:33-31 | Bone meal | |
| 61:l,v:1,5,7 | 26:23-30 | Meat and bone meal | Jamaican turtle |
| 61:k:1,5,7 | 26:29-30 | Dog food, oats | |
| 61:l,v:$z_{35}$ | 26:23-21 | | Indonesian frogs' legs, Bean sprouts |
| 65:(k):z | 30:22:31 | Argentinian crushed bone | |

*Drug resistance*

Drug resistance studies were carried out on 109 strains from different sources. One hundred and three (94%) strains were sensitive to all antibiotics. One strain of serotype *Sa* 48:i:z isolated from a 4-month-old child was resistant to tetracycline only. Serotype *Sa* 50:$z_{52}$:$z_{35}$ isolated from a 1-month-old baby was resistant to streptomycin and tetracycline. The remaining strains were resistant to four or more antibiotics; one was of serotype *Sa* 61:l,v:$z_{35}$ from an adult and three were of serotype *Sa* 61:l,v:1,5,7 isolated from terrapins.

## DISCUSSION

Edwards, Fife and Ramsey [2] in their study of arizona infections found 30% of human infections were from blood or localised lesions. Weiss and colleagues [17] in a later study reported that 26% of infections were extra-intestinal. During the period of our survey we received only two blood culture isolations. *Sa* 61:c:$z_{35}$, which was isolated from a 13-year-old girl receiving steroids. The isolation of *Sa* 48:i:z was from an adult male. Both patients were excreting the same serotype in their stools as was isolated from blood. All other human strains received were from faecal culture. Fifty-five patients had enteritis, six were symptomless, and the clinical details of three were not known.

Sixteen patients (24%) were under the age of 1 year. The youngest, aged 2 weeks, had never been out of hospital. Eleven (17%) children belonged to the 1–4 year age group, and five (8%) were aged between 5 and 14 years. Thirty-one (47%) of the isolations were from adults and the age of three patients (4%) was not known. The preponderance of infections in infants and young children cannot be explained.

The most common serotype in humans was *Sa* 61:l,v:1,5,7 and five of these patients gave a history of foreign travel. This was also the most common serotype

isolated from terrapins. *Sa* 61 : c : $z_{35}$ was isolated in 1966 from two children and the terrapin tank water in their home. The index case, one of the children aged 3 years, had the habit of putting terrapins in her mouth [15].

The importance of snakes as a source of *S. arizonae* infections should not be overlooked. The two isolations of *Sa* 17 : $z_{10}$ : e,n,x,$z_{15}$ were from children looked after by the same child minder who kept a pet snake which was found to be excreting the same serotype. One of the isolations of *Sa* 61 : l,v : 1,5,7 was from a snake breeder who kept a snake excreting the same serotype. In one household where snakes were kept a sibling of 20 months was infected with *Sa* 65 : (k) : $z_{53}$. Eight months later the baby sister of 1 month was infected with *Sa* 50 : $z_{52}$ : $z_{35}$ and 6 months later *Sa* 48 : i : z was isolated from the same baby. It is not known if cultures were made from the snakes. Five other human infections were from households where snakes were kept as pets. The serotypes were *Sa* 41 : $z_4$,$z_{23}$ : -, *Sa* 50 : k : z, *Sa* 53 : r : $z_{35}$, *Sa* 61 : l,v : 1,5,7 and *Sa* 61 : r : $z_{53}$. Weiss and colleagues [17] reported that snakes were an important reservoir in the USA.

The occurrence of *Sa* 18 : $z_4$,$z_{32}$ : - in turkeys in 1968 was traced to a breeding flock imported as day-old poults from California, USA. The spread of this infection to other poultry and humans was prevented by the slaughter of the original breeding flock and only breeding from the F1 generation found free of *S. arizonae* on serological testing [17]. This serotype was widely distributed in turkeys in the USA [2]. In a recent survey of arizona serotypes in the USA Weiss and colleagues [18] found *Sa* 18 : $z_4$,$z_{32}$ : - to be the most common serotype from humans, accounting for 20% of the human isolations. This serotype has never been isolated from a human in the UK.

Serotype *Sa* 61 : k : 1,5,7 has become established in the ovine population. It first appeared in sheep in 1976 [18] and in 1989 was the third most common serotype found in sheep [19]. During the period of our survey *Sa* 61 : k : 1,5,7 has also been isolated from abattoir drains on 17 occasions. There were only two human infections with this serotype and one of the patients had been abroad.

The isolations of *Sa* 18 : $z_4$,$z_{32}$ : - and *Sa* 18 : $z_4$,$z_{23}$ : - from Italian pasta in 1967 and 1968 might have been due to egg because eggs and egg products have been a source of both these serotypes in the USA [2]. This type has never been isolated from humans in the UK.

In 1988 there was a food poisoning outbreak in which bean sprouts were the vehicle; *Salmonella saint-paul* was the predominant epidemic serotype [20]. During investigations *Sa* 61 : l,v : $z_{35}$ was isolated from bean sprouts germinated in a Chinese restaurant. The country of origin of these beans was never established, but they were probably imported into the UK. There were no related human isolations of this serotype.

This study shows that *S. arizonae* are uncommonly isolated in the UK and 35% of the human infections were associated with foreign travel. However, if *S. arizonae* are isolated from young children with no history of foreign travel, the possibility of contact with terrapins or other reptiles especially snakes should be considered.

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