*J. Hyg., Camb.* (1983), **91**, 429–436
*Printed in Great Britain*



# The herring gull *Larus argentatus* as a carrier of salmonella

By JENNIFER BUTTERFIELD, J. C. COULSON, SUSAN V. KEARSEY[1], PATRICIA MONAGHAN[2],

*Zoology Department, University of Durham, South Road, Durham, DH1 3LE*

J. H. McCOY[3] and G. E. SPAIN

*Public Health Laboratory, Hull Royal Infirmary, Anlaby Road, Hull, HU3 2JZ*

(*Received* 4 *July* 1983; *accepted* 11 *July* 1983)

## SUMMARY

The proportion of salmonella carriers among town-nesting herring gulls increased significantly from 2·1 % in 1975–6 to 8·4 % in 1979. The range of serotypes carried by herring gulls was similar to that causing infection in man, and it is likely that the gulls ingest these serotypes when feeding at untreated sewage outfalls on the coast. This is supported by the proportion of salmonella carriers being higher among first-year birds (9·7 %) than among older birds (2·0 %), as it is known that higher proportions of immature herring gulls feed on the coast. Herring gulls carrying salmonellas appeared healthy at the time of capture and at a later date it was assumed that they were not themselves infected. However, their habit of congregating in large numbers on reservoirs and rubbish tips and also at resting sites on farmland often far from feeding and roosting areas, multiplies the pollution problem and increases the potential health hazard for both man and farm stock. Herring gulls feed at a variety of sites and fly many miles from food source to food source and from feeding areas to the roost. Thus, even within the same day, there is the possibility of the transfer of salmonellas over a much wider area than previously considered.

## INTRODUCTION

In the past 50 years the herring gull population has increased dramatically in Europe (Cramp, Bourne & Saunders, 1974; Harris, 1970) and we calculate that there are now more than 20000 birds for each individual nesting in England and Wales at the beginning of the century. Accompanying this population explosion, the birds show an increased association with man and domestic animals. As island and cliff nesting sites become saturated, herring gulls move inland to nest on roofs in towns (Monaghan & Coulson, 1977) or in the uplands and moorlands which form part of water catchment areas (Duncan, 1981). Outside the breeding season, there are many water storage reservoirs which act as overnight roosts for thousands of

[1] Present address: 2 Pippin Walk, Hardwick, Cambridge, CB3 7QD.
[2] Present address: Zoology Department, The University, Glasgow, G12 8QQ
[3] Present address: 11 Riplingham Road, Kirkella, Hull, HU10 7TS.

wintering gulls (Hickling, 1977). In addition, the herring gull is highly mobile and exploits a great variety of food sources, from sewage outfalls and rubbish tips to fish at sea and the invertebrates of pasture and seashore.

These nesting, roosting and feeding habits mean that herring gulls may be in a position to transfer pathogens from contaminated sources to previously uninfected human beings or farm stock. A number of authors (e.g. MacDonald & Brown, 1974; Williams, Richards & Lewis, 1976) have shown that herring gulls carry a wide range of salmonellas. which are pathogenic to man and domestic animals. Williams *et al.* (1977) have demonstrated the transfer of *Salmonella livingstone* to cattle from herring gull faeces, and Crewe (1967) implicates gulls in the spread of *Cysticercus bovis*, the larval form of the beef tapeworm (*Taenia saginata*).

In the present study the salmonella serotypes isolated from herring gulls are compared with those causing infection in man and farm stock during the period of the study. It is suggested that gulls have the potential to spread infection over considerable distances.

## MATERIALS AND METHODS

Samples were taken either as the complete cloaca from culled herring gulls or on a swab from the cloaca of live birds caught at rubbish tips. The culled herring gulls were roof-nesting birds killed by $\alpha$-chloralose baits during the breeding season (mid May–mid June in the years 1975–79 inclusive) by the local authorities in Sunderland, Scarborough, Whitby and Staithes in north-east England. On rubbish tips the gulls were caught by cannon nets and later released. The catching period extended from December 1978 to December 1979, and the tips used extended from Lancaster on the west coast to Scremerston on the Northumberland coast and to Scarborough in north Yorkshire (Table 4).

### *The isolation and identification of salmonella*

On arrival at the microbiological laboratory, the cloaca was held by forceps and a swab was inserted to obtain faecal material for direct plating on bismuth sulphite agar, The cloacal tissue was then immersed in sterile tetrathionate broth (Rolfe, 1946). Cloacal swabs from trapped live birds were similarly treated, and culture plates and enrichment broth were incubated aerobically for 18 h at 37 °C. Enrichment broths were plated on bismuth sulphite agar incubated aerobically for 18 h at 37 °C.

After incubation the direct and indirect culture plates were examined using a 8× hand lens for the presence of characteristic salmonella colonies (McCoy & Spain, 1969). The typical salmonella colony with a black centre and a clear periphery is produced by the reduction of bismuth sulphite to sulphide in the presence of glucose.

Typical single colonies were individually subcultured on to nutrient agar slopes moistened with nutrient broth and incubated at 37 °C for at least 5 h. At this stage serological screening of the isolate using polyvalent somatic and flagellar antisera was carried out. Any strain showing agglutination with both polyvalent sera, or with polyvalent flagellar serum alone, was serologically identified using the individual somatic group sera and monophasic flagellar sera. Any strain producing dubious serological findings was checked biochemically to confirm its identity.

Table 1. *Salmonella serotypes isolated from herring gulls in the north of England between 1975 and 1979*

| Salmonella serotypes | Time and place of sampling | | | | | |
|---|---|---|---|---|---|---|
| | 1975–6 A | 1976 B | 1976 C | 1978 D | 1979 E | 1978–9 F |
| *S. typhimurium* | 0 | 0 | 0 | 0 | 4 | 12 |
| *S. hadar* | 0 | 0 | 0 | 0 | 3 | 10 |
| *S. heidelberg* | 0 | 0 | 0 | 8 | 5 | 10 |
| *S. agona* | 1 | 0 | 0 | 2 | 2 | 5 |
| *S. derby* | 0 | 0 | 0 | 0 | 0 | 4 |
| *S. virchow* | 0 | 0 | 0 | 0 | 0 | 3 |
| *S. infantis* | 0 | 0 | 0 | 0 | 0 | 2 |
| *S. anatum* | 1 | 0 | 0 | 0 | 0 | 0 |
| *S. stanley* | 1 | 0 | 0 | 0 | 0 | 0 |
| *S. brandenburg* | 0 | 0 | 1 | 0 | 0 | 0 |
| *S. indiana* | 0 | 0 | 1 | 0 | 0 | 1 |
| *S. give* | 0 | 0 | 1 | 0 | 0 | 0 |
| *S. livingstone* | 0 | 0 | 1 | 1 | 3 | 0 |
| *S. senftenberg* | 0 | 1 | 0 | 0 | 0 | 0 |
| *S. poona* | 0 | 1 | 0 | 0 | 0 | 0 |
| *S. bovis-morbificans* | 0 | 0 | 0 | 1 | 0 | 0 |
| *S. taksony* | 0 | 0 | 0 | 1 | 0 | 0 |
| *S. saint-paul* | 0 | 0 | 0 | 0 | 1 | 1 |
| *S. montevideo* | 0 | 0 | 0 | 0 | 1 | 0 |
| *S. braenderup* | 0 | 0 | 0 | 0 | 0 | 1 |
| *S. bredeney* | 0 | 0 | 0 | 0 | 0 | 1 |
| *S. haardt* | 0 | 0 | 0 | 0 | 0 | 1 |
| *S. kedougou* | 0 | 0 | 0 | 0 | 0 | 1 |
| *S. tennessee* | 0 | 0 | 0 | 0 | 0 | 1 |
| *S. panama* | 0 | 0 | 0 | 0 | 0 | 1 |
| *S. thompson* | 0 | 0 | 0 | 0 | 0 | 1 |
| Total number of infections found | 3 | 2 | 4 | 13 | 19 | 55 |
| Total number of birds sampled | 99 | 141 | 124 | 261 | 227 | 1934 |
| Percentage of birds infected | 3·0 | 1·4 | 3·2 | 5·0 | 8·4 | 2·8 |

A, Sunderland rooftops; B, Scarborough harbour and Whitby rooftops; C, Scarborough tip; D & E, Scarborough, Whitby and Staithes rooftops; F, tips in County Durham, Northumberland and North Yorkshire.

Salmonellas of particular serotypes, e.g. *S. typhimurium*, *S. hadar* or *S. thompson*, were further differentiated by bacteriophage typing to facilitate epidemiological investigation.

## RESULTS

### *Recent increase in the proportions of herring gulls carrying Salmonella*

Table 1 shows the number of salmonella serotypes isolated from herring gulls caught in towns and on rubbish tips between 1975 and 1979. The proportion of birds carrying salmonellas among the adult birds taken during the breeding season in towns has risen from 2·1% in 1975–6 (combined total for columns A and B



https://doi.org/10.1017/S0022172400060460 Published online by Cambridge University Press

Table 2. *The percentage occurrence of the six most common salmonella serotypes found in herring gulls compared with the six most common serotypes recorded as causing infection in man, poultry and cattle respectively during the period from 1975–1979 in northern England*

| salmonella serotypes | Percentage occurrence | | | |
|---|---|---|---|---|
| | Herring gull | Man | Poultry | Cattle |
| *S. heidelberg* | 24 | 10 | 29 | 2 |
| *S. typhimurium* | 17 | 18 | 4* | 40 |
| *S. hadar* | 14 | 3 | (4) | 1 |
| *S. agona* | 10 | + | 26 | 1 |
| *S. livingstone* | 5 | 0 | 5 | 0 |
| *S. derby* | 4 | + | + | + |
| *S. anatum* | + | 2 | + | 1 |
| *S. indiana* | + | 2 | + | 0 |
| *S. bredeney* | + | + | 5 | 0 |
| *S. senftenberg* | + | + | 5 | + |
| *S. enteritidis* | 0 | 29 | + | + |
| *S. dublin* | 0 | 0 | 0 | 51 |
| Total number of identified isolations | 96 | 206 | 652 | 384 |
| Number of serotypes identified | 26 | 26 | 37 | 17 |
| Contributed by the six most common serotypes | 74 | 64 | 74 | 96 |

There was one notified case from Middlesbrough (1975–78) and Scarborough (1975–79) Environmental Health Departments, and there were two incidents in statutory animals in north-east England.

\+ Present but not contributing to the six most common serotypes.

* Two serotypes are present at the 4% level occupying sixth and seventh place.

in Table 1) to 5·0% in 1978 and 8·4% in 1979. This increase is significant ($\chi^2_2 = 9{\cdot}6$, $P < 0{\cdot}01$) and suggests that the proportion of roof-nesting herring gulls carrying salmonellas has increased over the five-year period.

There is a highly significant difference ($\chi^2_1 = 14{\cdot}5$, $P < 0{\cdot}001$) between the proportion of roof-nesting birds carrying salmonellas (6·6%) and the proportion of carriers caught on rubbish tips (2·8%) in 1978 and 1979. This may reflect the different date of sampling or different food sources used by the birds (Section 4). The differences in the proportions of each serotype carried by the town-culled birds and the herring gulls caught at rubbish tips were not significant.

*Comparison between the range of salmonella serotypes found in gulls with those causing infection in man and domestic animals.*

Table 2 shows the percentage occurrence of the six most common salmonella serotypes found in herring gulls compared with the six most common serotypes recorded as being the cause of infection in man, poultry and cattle respectively. It is apparent that the spectrum of the more commonly occurring salmonellas isolated from herring gulls is similar to those found in human beings (the high incidence of *S. enteritidis* in human beings was largely attributed to a single source of infection) and poultry but very different from that in cattle. *Salmonella dublin*,

https://doi.org/10.1017/S0022172400060460 Published online by Cambridge University Press

Table 3. *The numbers of colour-ringed gulls, found to be carrying salmonellas when ringed, seen in subsequent months*

| salmonella serotypes | No. of gulls carrying serotype | No. of gulls seen later | No. of gulls not seen |
|---|---|---|---|
| *S. typhimurium* | 4 | 3 | 1 |
| *S. hadar* | 4 | 2 | 2 |
| *S. agona* | 3 | 1 | 2 |
| *S. derby* | 2 | 1 | 1 |
| *S. virchow* | 1 | 1 | — |
| *S. tennessee* | 1 | 1 | — |
| *S. haardt* | 1 | 1 | — |
| *S. thompson* | 1 | 1 | — |
| *S. indiana* | 1 | 1 | — |
| *S. heidelberg* | 1 | 1 | — |
| Total | 19 | 13 | 6 |

which is the cause of 51 % of the outbreaks in cattle, was not isolated from herring gulls.

*The infection of herring gulls by salmonella*

Nineteen herring gulls which showed no sign of clinical infection, but from which positive isolations of ten salmonella serotypes had been made, were each ringed with a unique combination of coloured leg rings and released. Table 3 shows that 13 (68 %) of these birds were seen alive at least a month after ringing and that at least one bird with each of the ten serotypes was still apparently healthy. Typically, we see about 70 % of herring gulls again after colour-ringing, so this result indicates that herring gulls carrying salmonellas are at no greater risk of mortality than the population at large. It is likely that, in most cases where positive isolations have been made, the herring gulls were acting as passive carriers or were, at the most, subclinically infected.

*The distribution of salmonella carriers within the herring gull population*

Table 4 shows the distribution of salmonella carriers among herring gulls according to age, season and catching site. In the summer the proportions of birds hatched that year (9·7 %) and older birds (2·0 %) carrying salmonellas differed significantly ($\chi_1^2 = 31{\cdot}2$, $P < 0{\cdot}001$). The relatively high proportion of first-year birds carrying salmonellas during the summer declined to a winter level of 3·2 %, which was not significantly different from the level of 1·4 % found among older birds during the same period. The decrease in the proportion of first-year birds carrying salmonellas between summer and winter was significant ($\chi_1^2 = 5{\cdot}0$, $P < 0{\cdot}05$), whereas the smaller decrease among older birds was not. It is apparent from Table 4 that the percentage of isolations from herring gulls caught on different refuse tips varied and this, together with the differences in the proportions of first-year and older birds caught, could bias the trend. At one refuse tip, Seaton Carew, virtually the same numbers of herring gulls, in the same age proportions, were caught in July–October as in November–February. Here the percentage of isolations dropped from 7·7 % in the summer to 2·9 % in the winter. In this case,

https://doi.org/10.1017/S0022172400060460 Published online by Cambridge University Press

Table 4. *The distribution of salmonella carriers among herring gulls according to age and season. The number of infected birds is listed in parentheses after the number of birds caught at each site*

| | | Catching period | | | |
|---|---|---|---|---|---|
| | | July–October | | November–February | |
| Rubbish tip | Map ref. | Older than first year | First year | Older than first year | First year |
| Seaton Carew | NZ 520310 | 208 (9) | 63 (12) | 208 (6) | 67 (2) |
| Coxhoe & Wingate | NZ 330364<br>NZ 371379 | 200 (4) | 6 (0) | 332 (3) | 33 (1) |
| Darlington | NZ 322117 | 31 (2) | 69 (10) | — | — |
| Scarborough | TA 018923 | 111 (0) | 0 (0) | — | — |
| Haydon Bridge | NY 890687 | 156 (1) | 27 (2) | — | — |
| Scremerston | NV 028483 | 108 (1) | 41 (1) | | |
| Consett | NZ 139517 | 76 (1) | 21 (0) | 72 (0) | 18 (0) |
| Lancaster | SD 458623 | 12 (0) | 31 (0) | 44 (0) | 0 (0) |
| Total number caught | | 902 (18) | 258 (25) | 656 (9) | 118 (3) |
| Percentage of total infected | | 2·0 | 9·7 | 1·4 | 2·5 |
| | | 3·7 | | 1·6 | |

as in the total sample, the decrease is largely accounted for by the decline in isolations from first-year birds; 19% in summer to 4% in winter ($\chi^2_1 = 7{\cdot}1$, $P < 0{\cdot}01$). The decrease shown among the older birds over the same period (4·3% to 2·9%) was not significant.

## DISCUSSION

It has been shown by many authors (e.g. Edel, Schothorst & Kampelmacher, 1976; Pagon, Sonnabend & Krech, 1974; Steiniger, 1970) that gulls carry a wide range of salmonella serotypes pathogenic to man and domestic animals. In the present study, we found that both the range of serotypes and the proportions in which the serotypes were present were more similar in gulls and human beings than in gulls and poultry or cattle. In particular, *S. dublin*, which caused 51% of the infections in cattle, was absent from the gulls. Similarly, Fenlon (1981) found that 72% of the serotypes isolated from human cases in the Grampian region of Scotland were also present in herring gulls and suggested that this was the consequence of the gulls' habit of feeding at untreated sewage outflows. Further, McCoy (1963) showed that salmonella serotypes from infected human beings are common at sewage outfalls.

We found that the proportion of salmonella carriers was significantly higher among first-year birds than among older herring gulls and, as Monaghan (1980) has shown that the proportions of immature herring gulls at the coast are greater than at other feeding sites, this also supports the suggestion that sewage outflows are the predominant source of contamination. The seasonal decrease in the number of young birds carrying salmonellas found in the present study may, presumably, reflect the decline in the number of infections among the human population during the winter.

https://doi.org/10.1017/S0022172400060460 Published online by Cambridge University Press

The probability that gulls pick up salmonellas at coastal outflows where untreated sewage is discharged, coupled with the apparent good health of individual herring gulls known to be carrying salmonellas, indicates that gulls are not the primary source of infection. This does not, however, mean that they can be dismissed as potential vectors of salmonellas to the human population. The numbers of salmonellas carried by individual herring gulls may be small, but the birds themselves congregate in tens of thousands on water storage reservoirs (Hickling, 1977) and cause considerable pollution problems (Fennell, James & Morris, 1974).

Williams *et al.* (1977) have shown that it is possible for salmonellas in gull faeces to be transferred to cattle and Johnson, Machlachlan & Hopkins (1979) have shown that there is a high probability that cattle were infected by drinking contaminated water from a loch used by gulls as a roost. However, it has frequently been demonstrated that the concentrations of salmonella required to infect healthy cattle and sheep (Taylor & Burrows, 1971; Browne, Ross & Smith, 1977; Hall & Jones, 1978) are usually many orders of magnitude greater than those found in gull faeces. Fenlon (1981) discussed this problem and, on the basis that starved or stressed animals are susceptible to much lower doses (Smith, 1977; Spence & Westwood, 1978), suggested that such animals might be at risk from transfer of salmonella infection by gulls in fields adjacent to untreated sewage outfalls. Once infected, because of the multiplication within the host, such animals could well become infective agents for surrounding stock. It is not only in fields adjacent to sewage that stock is at risk of infection. Herring gulls feed at a variety of food sources and fly many miles from feeding site to feeding site and from feeding site to day or night roosts. If stock is susceptible to infection with gull-borne salmonellas it will be at risk in any field where gulls congregate. Equally, stock will be at risk if its water supply is contaminated by roosting gulls (Johnson *et al.* 1979). In cases of unexplained outbreaks of salmonellosis, especially among grazing animals, the possibility of transfer from gulls should be considered.

We wish to acknowledge Scarborough Borough Council and South Tyneside District Council for making culled herring gulls available and the Environmental Health Departments of Middlesbrough Borough Council and Scarborough Borough Council for information on human cases of salmonella infection. The Ministry of Agriculture, Fisheries and Food Epidemiology Unit, CVL, supplied the information on salmonella incidents among statutory animals in the north-east of England. We would like to thank Durham County Council, Tyne and Wear County Council, Northumberland County Council, Lancashire County Council, Cleveland County Council, Darlington Borough Council and Scarborough Borough Council for allowing us to catch at their rubbish tips. We are grateful to all those who helped us catch and process the birds. This work was carried out as part of a larger study on the pathogenic organisms carried by gulls, on a grant from the Natural Environment Council.

## REFERENCES

BROWN, D. D., ROSS, J. G. & SMITH, A. F. G. (1977). Experimental infection of sheep with *Salmonella infantis*. *British Veterinary Journal* **133**, 435–441.

CRAMP, S., BOURNE, W. R. P. & SAUNDERS, D. (1974). *The Seabirds of Britain and Ireland*. London: Collins.

CREW, S. M. (1967). Worm eggs found in gull droppings. *Annals of Tropical Medicine and Parasitology* **61**, 358.

DUNCAN, N. (1981). The Abbeystead and Mallowdale gull colony before control. *Bird Study* **28**, 133–138.

EDEL, W., SCHOTHORST, M. VAN, KAMPELMACHER, E. H. (1976). Epidemiological studies on *Salmonella* in a certain area ('Walcheren Project'). The presence of *Salmonella* in man, pigs, seagulls and in foods and effluents. *Zentralblatt für Bakteriologie Parasitenkunde Infektionskrankheiten und Hygiene*. I. Abt. Orig. A. **325**, 476–484.

FENLON, D. R. (1981). Seagulls (*Larus* spp.) as vectors of salmonellae: an investigation into the range of serotypes and numbers of salmonellae in gull faeces. *Journal of Hygiene* **86**, 195–202. **86**, 195–202.

FENNELL, H., JAMES, D. B. & MORRIS, J. (1974). Pollination of a storage reservoir by roosting gulls. *Water Treatment and Examination* **23**, 5–2.

HALL, G. A. & JONES, P. W. (1978). A study of the susceptibility to oral infection by salmonellas contained in raw sewage sludge. *Journal of Hygiene* **80**, 409–414.

HARRIS, M. P. (1970). Rates and causes of increases of some British gull populations. *Bird Study* **17**, 325–335.

HICKLING, R. A. O. (1977). Inland wintering of gulls in England and Wales. *Bird Study* **24**, 79–88.

JOHNSTON, W. S., MACLACHLAN, G. K. & HOPKINS, G. F. (1979). The possible involvement of seagulls (*Larus* spp.) in the transmission of salmonella in dairy cattle. *Veterinary Record* **105**, 526–527.

MACDONALD, J. W. & BROWN, D. D. (1974). *Salmonella* infection in wild birds in Britain. *Veterinary Record* **94**, 321–322.

MCCOY, J. H. (1963). Salmonellae in crude sewage, sewage effluent and sewage-polluted natural waters. *International Journal of Air and Water Pollution* **7**, 597–611.

MCCOY, J. H. & SPAIN, G. E. (1969). Soc. Appl. Bact. Tech. Series No. 3. *Isolation Methods for Microbiologists*, pp. 17–27 (ed. D. A. Shapton and G. W. Gould). London: Academic Press.

MONAGHAN, P. (1980). Dominance and dispersal between feeding sites in the herring gull (*Larus argentatus*). *Animal Behaviour* **28**, 521–527.

MONAGHAN, P. & COULSON, J. C. (1977). Status of large gulls nesting on buildings. *Bird Study* **24**, 89–104.

PAGON, S., SONNABEND, W. & KRECH, U. (1974). Epidemiologic relationships between human and animal *Salmonella* carriers and their environment in the Swiss region of the Lake of Constance. *Zentralblatt für Bakteriologie Parasitenkunde Infektionskrankheiten und Hygiene*. I. Abt. Orig. B **158**, 395–411.

ROLFE, V. (1946). Note on the preparation of tetrathionate broth. *Monthly Bulletin of the Ministry of Health and Public Health and Public Health Laboratory Service* **5**, 158.

SMITH, M. G. (1977). Transfer of R factors from *Escherichia coli* to salmonellas in the rumen of sheep. *Journal of Medical Microbiology* **10**, 29–35.

SPENCE, J. B. & WESTWOOD, A. (1978). *Salmonella agona* infection in sheep. *Veterinary Record* **102**, 332–336.

STEINIGER, F. (1970). Transport of micro-organisms by migratory birds between Europe and South Africa, in relation to bird-ringing and disinfection. Panafrican Ornithological Congress 1969. Pretoriuskop. Abstr. 283–297.

TAYLOR, R. J. & BURROWS, M. R. (1971). The survival of *Escherichia coli* and *Salmonella dublin* in slurry on pasture and the infectivity of *S. dublin* for grazing calves. *British Veterinary Journal* **127**, 536–542.

WILLIAMS, B. M., RICHARDS, D. W. & LEWIS, J. (1976). *Salmonella* infection in the herring gull (*Larus argentatus*). *Veterinary Record* **98**, 51.

WILLIAMS, B. M., RICHARDS, D. W., STEPHENS, D. P. & GRIFFITHS, T. (1977). The transmission of *S. livingstone* to cattle by the herring gull (*Larus argentatus*). *Veterinary Record* **100**, 450–451.