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The herring gull *Larus argentatus* as a likely transmitting agent of *Salmonella montevideo* to sheep and cattle

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SUMMARY

This paper presents evidence for the involvement of herring gulls (*Larus argentatus*) as vectors in the recent outbreaks of *Salmonella montevideo* in sheep and cattle in Scotland and suggests that the transfer can take place over considerable distances. The breeding area in Scotland of herring gulls which overwinter in N.E. England is remarkably similar to the geographical distribution of the outbreaks. This pattern, together with the feeding behaviour of herring gulls on farmland, the presence of *S. montevideo* in herring gulls just before their departure from the wintering area and the timing of the return just before the peak of outbreaks are all circumstantial evidence implicating this gull in the outbreaks. The rapid return of these gulls to their breeding areas means that *S. montevideo* can be transported long distances in one day and raises the possibility that the original source of *S. montevideo* could have been in N.E. England rather than in Scotland.

INTRODUCTION

In a recent paper Sharp *et al.* (1983) have described the increase in cases of abortion in sheep in Scotland caused by *Salmonella montevideo*. They also draw attention to the unusual geographical distribution of cases of *S. montevideo* in sheep and cattle in Scotland. They conclude that movements of domestic stock cannot account for the spread or the distribution of cases and suggest that wild birds may be implicated. Independent of their studies, we have been involved in an investigation of the extent to which gulls (*Larus* spp.) carry micro-organisms which are potentially capable of causing disease in domestic animals. Our investigations have been centred in N.E. England with supplementary work in SE Scotland. Our information, when considered with that collected by Sharp *et al.* (1983), strongly suggests that the herring gull is very likely to be the agent which has transmitted *S. montevideo* to sheep and cattle both locally and over considerable distances in Scotland. Further, we present evidence that herring gulls are responsible for the characteristic distribution of cases on the east side of Scotland.

MATERIALS AND METHODS

Salmonella serotypes have been isolated from cloacal swabs from gulls and the methods have been reported by Butterfield *et al.* (1983) and Butterfield *et al.* (in

preparation). Samples were taken mainly in N.E. England and in S.E. Scotland from gulls caught in cannon nets used at refuse tips or from adults culled during control measures between 1976 and 1982. Unfledged chicks were also sampled on islands in the Firth of Forth.

A large scale ringing programme was carried out in order to study the movements of gulls. Since 1978, over 10000 gulls have been marked with standard British Trust for Ornithology rings which requested the finder to return rings and recovery details to the British Museum (Natural History) from where the B.T.O. informs the ringers. Herring, great and lesser black-backed, common and black-headed gulls were marked, mainly during the winter half of the year, and we have accumulated extensive information concerning their movements. In addition to the B.T.O. ring, many herring and great black-backed gulls were each given a unique combination of coloured rings. This enabled observers to record many of these birds on their breeding areas. The marking of birds for individual identification also allowed us to identify the time of departure in the winter and spring from a study area near Durham City and to record local movements to different feeding sites.

RESULTS

The case we make for the implication of the herring gull in the transmission of *S. montevideo* depends upon:

(1) The presence of this organism in the herring gull.

(2) The movements of herring gulls from their wintering areas to the breeding areas.

(3) The timing of the movements back to the breeding area and the coincidence of this return with the outbreaks of *S. montevideo* infections.

(4) The use of agricultural land as feeding areas by herring gulls in eastern Scotland.

(1) *The presence of* S. montevideo *in herring gulls*

During studies of salmonella in gulls, we have recorded *S. montevideo* on nine occasions. Eight of the isolations were from herring gulls and one from a black-headed gull. The isolations were in February (three), May, June, July (three) and November (Table 1). The February records are of particular significance since this was just before the gulls leave the wintering area to return to Scotland. The first isolation of *S. montevideo* was not made until 1979 and occurrences have increased in recent years, coinciding with the increase of infection in sheep and cattle in Scotland (Table 1). Most of the isolations were from herring gulls; this was because we examined large numbers of this gull rather than because this species carried salmonella to a greater extent.

(2) *The breeding area of gulls wintering in S.E. Scotland and N.E. England*

We can summarise the results of the extensive ringing of gulls we have carried out in N.E. England (mainly Co. Durham).

Herring gulls (Larus argentatus). About 20% of the birds wintering in N.E. England breed in arctic Norway. The remaining birds breed along the whole east coast of Scotland as far north as Orkney and Shetland with only a few nesting in

Table 1. *The number of gulls examined for salmonella, the number of isolations and the number of occurrences of* S. montevideo *according to gull species and year*

(A) Isolation of salmonella in gull species

Species	No. examined	No. of isolations of salmonella (and percentages)	No. of isolations of *S. montevideo* (and percentages)
Herring gull	4636	170 (3·7)	8 (0·2)
Black-headed gull	416	12 (2·9)	1 (0·2)
Lesser black-backed gull	50	6 (12)	0
Great black-backed gull	29	0	0
Common gull	33	0	0

(B) Isolations in herring and black-headed gulls in relation to year

	1975–78	1979	1981	1982
Number of gulls examined	749	2037	1550	716
No. of salmonella isolates	23	73	54	32
No. of *S. montevideo* isolates	0	1	2	6
Percentage of *S. montevideo* in isolates	0·0%	1·4%	3·7%	18·9%
Month of *S. montevideo* isolates		May	June November	3 February 3 July

N.E. England. The distribution map of the recoveries or sightings of these birds shown in Fig. 1 together with the distribution map of *S. montevideo* outbreaks in sheep and cattle reported by Sharp *et al.* (1983). The similarity of these two distributions is remarkable. It should also be noted that the number of isolations from cattle and sheep is much greater on the east than on the west side of northern England. It should be noted that the herring gull shows little inclination to cross between the east and west coasts of Britain and that the movements are almost entirely restricted to the coast on which they breed. This pattern of movement is of considerable importance in relation to the distribution of *S. montevideo*.

Black-headed gull (Larus ridibundus). Almost all of the ringing returns in the summer half of the year are from the European continent and apparently very few British breeding birds winter in N.E. England. The wintering birds breed in most of the countries around the Baltic Sea and travel as far as Finland and Estonia S.S.R. None were recovered in Scotland.

Common gull (Larus canus). Relatively few common gulls were ringed but the indication is that many of these are of continental origin with several recoveries in Norway and one in Finland. Although this species breeds in Scotland, none of those we ringed were recovered there.

Great black-backed gull (Larus marinus). The birds wintering in N.E. England were almost entirely from the Norwegian breeding population and there was the possibility that some birds orginated in the Murmansk region of USSR (Coulson *et al.* 1983). Only one recovery in the breeding season was from Scotland and we failed to find any of our colour-ringed birds breeding on the east coast of Scotland.

Lesser black-backed gull (Larus fuscus). This bird is a rare overwintering bird in N.E. Britain and many migrate to and from Iberia and north Africa. Apart from the Firth of Forth area, it does not breed in numbers in eastern Scotland and is outnumbered by at least 100 to one by herring gulls along the Scottish coast

Fig. 1. Maps of the north of England and Scotland showing (A) the position of incidents of *S. montevideo* in sheep and cattle in Scotland (after Sharp *et al.* 1983) and in northern England between 1975 and 1982 (data from C.V.L. of M.A.F.F.) and (B) the breeding area in Scotland and N.E. England of herring gulls wintering in N.E. England around Durham City. The large dots indicate the records of five different birds and the small dots single birds. We found very few instances of herring gulls moving to the west coast of Scotland. Note the similarity between the distribution of incidents and of the gulls, particularly when it is remembered that many of the gulls move inland to feed from the breeding colonies on the coast where they were recorded.

between St Andrews and Caithness. Thus whilst birds of this species undoubtedly pass through eastern Scotland, the numbers involved are much smaller than for the herring gull.

Of the gull species considered, only the herring gull is present in large enough numbers and moves through the appropriate area to be a major vector of *S. montevideo*. We are not aware of any other bird species whose numbers and movements are such that it could result in the spread of infection along the whole eastern side of Scotland but not affect the western side of the country.

(3) *The time of movements of the herring gull*

The movement of herring gulls from the breeding areas starts surprisingly early. We have had two cases of marked birds nesting in Orkney and Shetland which had returned to the N.E. England by late July. These were probably birds which had failed in their breeding attempt but it is clear that their movement was rapid. It must be appreciated that many herring gulls which breed in Scotland remain there throughout the year, however the minority which moves south consists of tens, if not hundreds, of thousands of adults and immatures. Most Scottish breeding birds which move south leave the breeding area between August and October but some do not depart until November and December.

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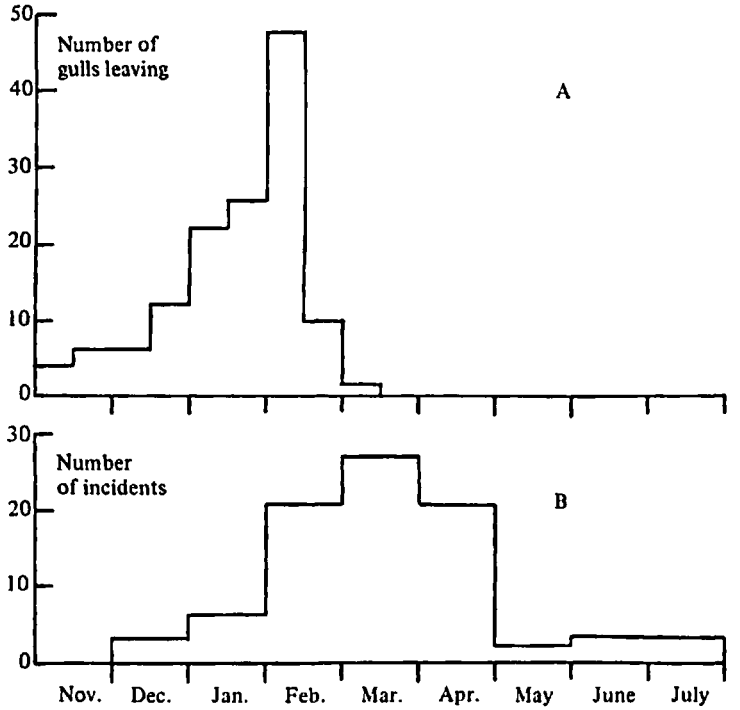

Fig. 2. The relationship between the timing of (A) departure of marked herring gulls from our study area near Durham and (B) the timing of incidents of *S. montevideo* in sheep and cattle in Scotland (after Sharp *et al.* 1983).

The return of these birds to the breeding areas is more synchronised. Males tend to return earlier than the females but the majority return in January and in the first half of February (Fig. 2). The birds remaining in the wintering area until February appear to have a synchronized departure with most departing in 1 or 2 days. Our evidence is that the return to the breeding area is rapid, probably occurring in a single flight in many instances, thus allowing micro-organisms carried in the gut to be transferred over the length of Scotland. If the departure of the herring gulls occurred after the peak of outbreaks of abortion, the case for this species being involved in the long distance transfer of *S. montevideo* would be weakened. However thousands of herring gulls are moving from England (and S.E. Scotland) back to their breeding areas along the east coast of Scotland in advance, by a few weeks only, of the peak of abortions in ewes (Fig. 2). The possibility that *S. montevideo* is being transferred long distances at a time when ewes are reaching the final weeks of their gestation period (and are, presumably, more susceptible to *S. montevideo*) may well be an important factor in increasing the extent of the problem.

(4) *The behaviour of herring gulls during the period February–April in eastern Scotland*

Many of the herring gulls which breed in eastern Scotland, in addition to finding food on the coast and at sea, feed on pastures, stubble and ploughed land, eating grain or earthworms. Feeding for worms is particularly common early in the

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morning when the worms are at or near the surface of the sward and the gulls may be absent from pastures for the rest of the day. Such feeding occurs for many kilometres inland and, in the spring, we have found herring gulls feeding in pastures over 30 km from the coast. Large concentrations of herring gulls occur at refuse tips, both on the coast and inland, (for example over 200 gulls were feeding alternatively at the Turriff, Grampian Region, refuse tip and in near-by pastures in April 1983, some 16 km from the coast).

DISCUSSION

In their analysis of the causes of infection of sheep and cattle by *S. montevideo*, Sharp *et al.* (1983) stated that the role of wildlife in spreading infection to neighbouring stock appears to have been of some importance and they refer to *S. montevideo* being isolated from faeces of unspecified birds on affected farms. They also cite the infection of sheep on an island 35 miles from the north coast of Caithness as further evidence of birds acting as vectors of infection. Our studies indicate that the herring gull is not only a possible vector on a local scale, but is capable of transferring *S. montevideo* over the whole length of Scotland. The evidence for the involvement of the herring gull is fourfold. Firstly, the herring gull alone of our gulls has a pattern of movement which is consistent with the distribution of infection in sheep and cattle. Not only do herring gulls move along the whole east coast of Scotland from their wintering area in N.E. England at an appropriate time in January and February but the observation that they rarely cross from the east to west coast in any numbers offers a good explanation for the relative scarcity of cases of *S. montevideo* in western Scotland. Secondly, herring gulls have been found in N.E. England and in S.E. Scotland carrying *S. montevideo*. Three of these cases in N.E. England occurred in early February, just before gulls returned to Scotland. Whilst we have not found herring gulls clinically ill with salmonellosis, an appreciable proportion of the gulls are carrying salmonellae in their guts (Butterfield *et al.* 1983). Thirdly, individual herring gulls appear to return rapidly to their breeding area in January and February, probably in a single flight in many cases, so there is every oportunity for salmonellae taken into the gut in the wintering area to be transported several hundreds of kilometres. Fourthly, the behaviour of the herring gull is consistent with the transfer of salmonella to sheep and cattle as the gulls feed in pastures both on the coast and inland. They also roost in large numbers in fields close to refuse tips (and in other fields in stormy weather). On a more local scale, individually marked herring gulls have been seen feeding at a wide range of sites on the same and on consecutive days. For example, birds have been found feeding at sewage outfalls and later in pastures many kilometres away and others at refuse tips and then on farmland. Whilst the salmonella load of individual herring gulls may be low, their habit of collecting together to feed or in resting flocks on pasture allows higher concentrations of salmonellae to be deposited on farm land. The gulls also visit feeding troughs put out for domestic animals, and this is a further situation where faecal material from gulls could be concentrated.

The evidence we present is still circumstantial; we have not demonstrated that gulls transfer *S. montevideo* to sheep and cattle. However, Williams *et al.* (1977)

have shown that salmonella in gull faeces on pastures can be transferred to cattle whilst Johnston, Maclachlan & Hopkins (1979) have recognised water contaminated by gull faeces as a route of infection in cattle.

When investigators of the epidemiology of salmonella outbreaks conclude that avian vectors are probably involved, the abundance of the herring gull, its patterns of feeding and movement, as well as its exceptional mobility, make it a very likely candidate as a vector. In the incidents of *S. montevideo* amongst sheep and cattle in Scotland, the implication of the herring gull also offers a satisfactory explanation of the unusual geographical distribution of cases. The involvement of the herring gull has the corollary that the main source of the *S. montevideo* may be outside Scotland and in N.E. England.

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