PAPER

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Incidence of Scottish Lyme disease appears to be related to the effects of weather on tick survival and human behaviour

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ABSTRACT This paper investigates the annual variation in the Lyme disease infection rates seen in different areas of Scotland from 1999 to 2003. We suggest that the combination of a warm, wet January to March (aiding tick survival) and a dry April to July (favouring increased human exposure) explained the increased incidence of Lyme disease observed in certain years during the study period. Human behavioural changes brought about by the countryside access restrictions enforced during the Foot and Mouth disease epidemic may have had an additional influence on the incidence of Lyme disease in the East of Scotland during 2001. This paper helps in our understanding of Scottish Lyme disease.

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LIST OF ABBREVIATIONS *Borrelia burgdorferi (B. burgdorferi), Ixodes ricinus (I. ricinus)*

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SUMMARY

The weather was investigated as a factor influencing the incidence of Lyme disease in Scotland (excluding Grampian and Northern Isles) from 1999 to 2003. Data on the incidence of laboratory confirmed Lyme disease in humans, monthly rainfall and temperature for North, East and West of Scotland during 1999 to 2003 were examined. The West of Scotland had a lower Lyme disease infection rate than the mean for the North and East (3·95± 1·16, 95% confidence limits). The West was warmer than the yearly mean temperature for the North and East (7·527± 0·69, 95% confidence limits), and wetter than the East (P<0·001, χ^2). In 2000, the driest April to July in the West (P<0·05, χ^2) coincided with the highest infection rate when compared with the mean for the other years (1·25± 0·566, 95% confidence limits). In contrast, in 2001, the coldest and driest January to March in the North (P<0·001, χ^2) coincided with a decline in the Lyme disease infection rate when compared with the mean for the other years (4·0± 0·70, 95% confidence limits). Our suggestion is that the combination of a warm, wet January to March (aiding tick survival) and a dry April to July (favouring increased human exposure) increases the incidence of Lyme disease. We believe that the countryside access restrictions that were enforced during the Foot and Mouth epidemic may explain the reduction in Lyme disease in 2001 in the East. Thus, as with all infections, human behavioural changes can modify cycles of infection that are weather dependent.

INTRODUCTION

Acquisition of Lyme disease is most common in the summer.[1, 2] Lyme disease is a multisystem disorder especially affecting the skin, joints, heart and nervous system, causing acute and chronic disease.[2, 3] In Europe, *B. burgdorferi,* the spirochaete that causes Lyme disease is transmitted to humans by the *I. ricinus* tick.[1] *I.ricinus* ticks feed on small and large mammals (including deer and sheep) and birds,[3] and exist in three forms: larva, nymph and adult.[4] Humans acquire Lyme disease mainly from infected nymphs, usually in late spring/early summer, and occasionally from adult ticks, in the cooler months.[5] Ticks require temperate conditions with high humidity such as woodland and low-lying grassland.[4] Non-feeding ticks in the winter (temperatures below 5°C) are particularly susceptible to drying out and require constant humidity levels.[4, 6] Tick activity increases in spring and early summer, when air temperature reaches about 7°C.[1] Individuals who live and work in areas infested by ticks or in neighbouring residential areas are considered at risk of getting Lyme disease.[5] Similarly, those who participate in outdoor activities such as hill walking and camping are at risk of infection.[1]

In 2001, the UK suffered an outbreak of Foot and Mouth disease. The epidemic, which lasted from February to September, resulted in the slaughter of 4·0 million sheep, cattle and pigs and led to severe restrictions in land access.[7] Interestingly, in the same year, a drop in the total number of laboratory confirmed cases of Lyme disease in Scotland (excluding Grampian and Northern Isles) was observed. A similar decline in the number of cases of Cryptosporidiosis in Scotland, which has been linked with the 2001 Foot and Mouth disease epidemic, has already been reported.[8] Here we consider the incidence of Lyme disease in Scotland from 1999 to 2003 and investigate the importance of weather and the Foot and Mouth disease epidemic.

MATERIALS AND METHODS

Data on the incidence of laboratory confirmed Lyme disease in humans for North (Highland and Western Isles), East (Borders, Fife, Lothian and Tayside) and West of Scotland (Argyll and Clyde, Ayrshire and Arran, Dumfries and Galloway, Greater Glasgow and Lanarkshire) during 1999 to 2003 were obtained from specimens sent to the National Lyme disease service laboratory, Raigmore Hospital, Inverness. No samples were submitted from Grampian and the Northern Isles as they carry out their own testing. Infection rate was calculated as cases/100 samples per year to enable direct comparisons to be made between areas from year to year to allow for any effect of different sample numbers. Monthly rainfall and temperature data for North, East and West of Scotland during 1999 to 2003 were obtained from the Meteorological Office.[9] The weather areas used by the Meteorological Office corresponded with the above testing areas, but included Grampian in the East of Scotland. Standard deviations from the mean with 95% confidence limits were calculated for the number of cases/100 samples and temperature for North, East and West of Scotland for each year between 1999 and 2003. Multivariate analysis was also carried out. The χ^2 test was used to determine significant area and yearly differences in rainfall.

RESULTS

Laboratory confirmed Lyme disease infection rates (number of cases/100 samples), rainfall and temperature data for the North, East and West of Scotland during 1999 to 2003 are shown in Figure 1. A number of area and yearly differences was identified.

The West of Scotland had a lower infection rate than both the North and East, with less cases/100 samples than the mean for the North and East (3·95± 1·16, 95% confidence limits); in 2000, the difference was not significant (Figure 1). Multivariate analysis confirmed significance. The West was noticeably warmer than the North and East when comparing mean yearly temperature (7·527± 0·69, 95% confidence limits), with the exception of 2001. The West was also significantly wetter than the East when total yearly rainfall was compared ($P<0·001, \chi^2$).

In 2000 there were more cases/100 samples in the West than the mean for the previous and following years (1·25± 0·566, 95% confidence limits)(Figure 1). Multivariate analysis confirmed significance. 2000 had significantly the driest April to July ($P<0·05, \chi^2$) and the second wettest January to March in the West (Figure 1). There was no significant change in yearly mean temperatures.

In contrast, Lyme disease infection rates in the North and East of Scotland were similar in all years except 2001, where there were noticeably less cases/100 samples compared to the mean of the other years (North: 4·0± 0·70, 95% confidence limits, East: 4·325± 0·954, 95% confidence limits)(Figure 1). Multivariate analysis did not confirm significance. 2001 had the driest January to March ($P<0·001, \chi^2$) and second driest April to July in the North, and the driest April to July ($P<0·02, \chi^2$) and second

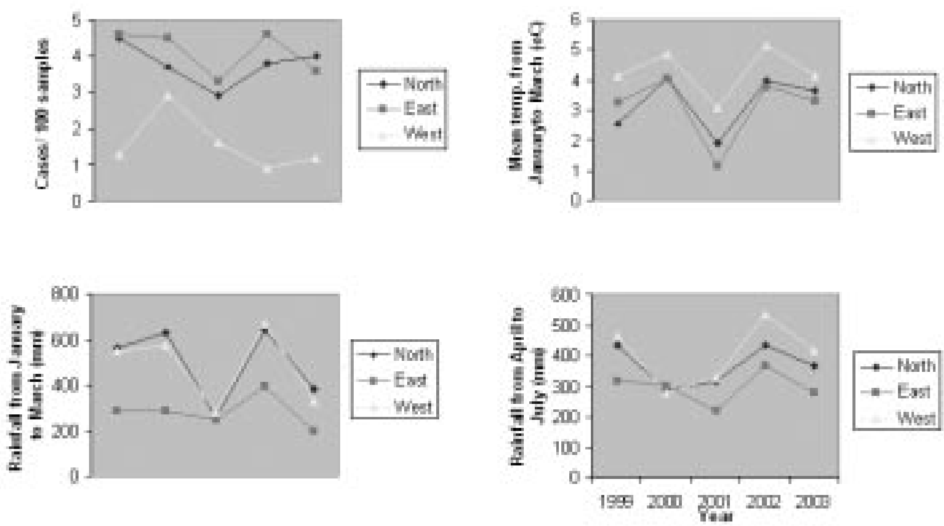

FIGURE 1 Incidence of Lyme disease and weather in North, East and West of Scotland, 1999 to 2003.

driest January to March in the East (Figure 1). There was no significant change in yearly mean temperatures although 2001 was noticeably the coldest in the period January to March in the North and East (3·55± 1·38 and 3·585± 0·796 respectively, 95% confidence limits) when compared with the means of the other years (Figure 1).

DISCUSSION

Our results show that there were significant differences in the three areas of Scotland. The West of Scotland had a lower Lyme disease infection rate than the North and East, and a different pattern of infection throughout the study period. Geographical differences in Lyme disease incidence have been widely reported, both between and within different countries.[5,10] These differences have been linked to tick density (determined by climate, vegetation type and spread and animal host density and behaviour)[11–13] and proportion of infected ticks (possibly determined by the abundance of reservoir hosts).[5] Unfortunately, there are no comprehensive data on the density and infection rate of ticks in the different areas of Scotland as only a few isolated studies have been carried out using different methods. A study by Davidson *et al.* found a 9% *B. burgdorferi* infection rate, determined by culture in ticks collected from two neighbouring sites in the Highlands (woodland and grassland).[14] In contrast, a study based on PCR found that 22% of ticks were infected on the East coast (mixed woodland) and 30% on the Island of Rum in the West.[15] These findings do not correlate with the popular view that Lyme disease is endemic only in the Highlands of Scotland.[14]

Two significant years have been identified. In 2000 the West had a peak in the rate of Lyme disease infection. This was coupled with the driest April to July in the West during the study period, suggesting that a dry April to July produces a higher incidence of Lyme disease. A higher Lyme disease incidence in the UK has previously been linked with warm, dry summers.[10] It is likely that outdoor human activity is increased in these conditions, therefore increasing human exposure to potentially infected ticks. Scottish tourism data indicate that although total visitor numbers declined in 2000 compared with 1999, Argyll, the Isles, Loch Lomond, Stirling and the Trossachs in the West were the only areas to see an increase in June. In July, increases in visitor numbers were found in two Western areas, Dumfries & Galloway and Ayrshire & Arran, plus Orkney and Shetland.[16] There was no peak in infection rate in the North and East in 2000, but these areas had no significant weather changes during this year.

In 2001, the rate of Lyme disease infection fell noticeably in the North. In this area, all years in the study period had a warmer and wetter January to March than 2001. This suggests that cold, dry winters may decrease the incidence of Lyme disease. A study on the American dog tick, *Dermacentor variabilis,* found that winter temperatures below 0°C resulted in a depressed tick population, as below these temperatures they were unable to resist dessication.[17] Interestingly, the North also had its driest April to July in 2001. However, a greatly decreased tick population may mean that the dry April to July period would have less of an effect on the incidence of Lyme disease than was seen in the West in 2000.

The rate of Lyme disease infection also fell noticeably in the East in 2001, which was unexpected in relation to the weather in this year. Although it had the coldest January to March, it was not the driest. Therefore, the tick population would not be expected to decrease as much as in the North. Consequently, as the East also had its driest April to July, the incidence of Lyme disease would not be expected to fall so significantly. It is possible that the potential for increased human exposure in the East due to the relatively dry April to July in 2001 may have been suppressed by the countryside access restrictions that were enforced throughout Scotland from Spring to Summer/Autumn as a result of the Foot and Mouth disease epidemic during this year.[8]

Visitor numbers to Scottish rural attractions were greatly reduced during 2001. Although the Scottish Borders and Perthshire saw a relatively small decline in May they had the largest decrease in visitor numbers compared with other tourist board areas in June and July. Decreased human exposure and the reduction of potential reservoir hosts due to the extensive culling of farm animals in the Borders and Dumfries and Galloway was part of the explanation for the reduction in cases of human Cryptosporidiosis in Scotland during the outbreak.[8] It is possible that the Foot and Mouth epidemic restrictions may have had an additional effect on the incidence of Lyme disease in the North, as visitor numbers to the Highlands were greatly reduced, although not as much as for the Scottish Borders and Perthshire in the East.[16] However, the January to March weather conditions provide an adequate explanation for the observed decline. There was no reduction in the Lyme disease infection rate in 2001 compared with other years in the West. However, the West always had a lower infection rate than either the North or East and April to July in 2001 in the West was not the driest. The low background may make observation of the effect of decreased human exposure difficult.

There is a large number of potentially confounding variables in this study, such as referral pattern, background tick density/infection rate and human behaviour. In addition, although infection rate was used to reflect incidence of infection, laboratory figures will be an underestimate of the true incidence of Lyme disease as many cases remain undetected, undiagnosed or are treated empirically. Although it is difficult to draw significant conclusions with these confounding variables and the short study period, some interesting trends have emerged that warrant further discussion and investigation.

In summary, our suggestion is that the combination of a warm, wet January to March (aiding tick survival) and a dry April to July (favouring increased human exposure) increases the incidence of Lyme disease. We believe that the Foot and Mouth epidemic may explain the reduction in Lyme disease in 2001 in the East. Thus, as with all infections, human behavioural changes can modify cycles of infection that are weather dependent.

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REFERENCES

1 Hendry G, Ho-Yen DO. *Ticks: A lay guide to a human hazard. Edinburgh:* Mercat Press: 1998;12–24, 40–4.
2 Steere AC. Borrelia burgdorferi. In: Mandell GL, Bennett JE, Dolin R (editors). *Mandell, Douglas, and Bennett's Principles and Practice of Infectious Diseases*. 5th ed. New York, USA: Churchill Livingstone; 2000; 2504–18.
3 Davidson MM, Evans R, Ho-Yen DO. Lyme disease: Gold for Scotland and Bronze for USA. *Scot Med J* 2003; **48:**6–9.
4 Parola P, Raoult D. Ticks and Tickborne Bacterial Diseases in Humans: An Emerging Infectious Threat. *CID* 2001; **32:**897–928.
5 Shapiro ED, Gerber MA. Lyme disease. *CID* 2000; **31:**533–42.
6 O'Connell S. Lyme disease in the United Kingdom. *BMJ* 1995; **310:**303–08.
7 Department for Environment, Foot and Rural Affairs. Statistics on Foot and Mouth disease. Available at: http://www.defra.gov.uk
8 Strachan NJC, Ogden ID, Smith-Palmer A *et al.* Foot and Mouth Epidemic Reduces Cases of Human Cryptosporidiosis in Scotland. *JID* 2003;**188:**783–6.
9 Met Office – UK climate and weather statistics. Available at: http://www.metoffice.com/climate/uk
10 Suback S. Effects of Climate on Variability in Lyme Disease incidence in the Northeastern United States. *Am J Epidemiol* 2003; **157:**531–8.
11 Sutherst RW, Maywald GF. A computerised system for matching climates in Ecology. Agric. *Ecosystems Environ* 1985; **13:**281–99.
12 Perry BD, Lessard P, Norval RAI *et al.* Climate, Vegetation and the Distribution of *Rhipicephalus appendiculatus* in Africa. *Parasitology Today* 1990; **6:**100–04.
13 Lindgren E, Talleklint L, Polfeldt T. Impact of climatic change on the Northern latitude limit and population density of the disease-transmitting European tick *Ixodes Ricinus*. *Environ Health Perspect* 2000;**108:**119–23.
14 Davidson MM, Evans R, Ling CL *et al.* Isolation of *Borrelia burgdorferi* from ticks in the Highlands of Scotland. *J Med Microbiol* 1999; **48:**59–65.
15 Curtin SM, Pennington TH. *Borrelia burgdoferi* studies in man and ticks in Scotland. In: Axford JS, Rees DHE (editors). *Lyme borreliosis*. New York: Plenum Press; 1994:147–54.
16 Scottish Visitor Attraction Barometer for 2000 & 2001. Available at htt p://www.scotexchange.net
17 McEnroe WD. The effect of mean Winter temperature around 0°C on the population size of the American dog tick *Dermacentor variabilis*, Say. *Acarologia* 1975; **XVII:**208–219.