



# **Ticks and Lyme disease – a study of awareness among the Scottish public and the potential market for a new preventative technology**

*Summary Report: January 2013*

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## **About Xeroshield**

Based at the Roslin Biocentre in Midlothian, Xeroshield is an SME established in 2005 to develop products and services using innovative technologies for insect control. Its business model is to formulate alternatives to the use of conventional chemical insecticides, carry out proof of concept studies with academic and industrial partners, and to generate IP for license and sale. Xeroshield's ethos is to produce solutions that are environmentally sustainable and available for use by the largest possible number of people in the shortest possible time.

Xeroshield has collaborated with many academic institutions in the UK and abroad, including Leeds University (England), Napier University (Scotland), Heriot Watt University (Scotland), Charles Darwin University (Australia), the Institut Pasteur (Tunisia), the University of Rajshahi (Bangladesh) and the University of Antioquia (Colombia).

Whilst working in collaboration with Leeds University, Xeroshield was the first Scottish company to receive a grant award from the Bill and Melinda Gates Foundation. Since then it has also received financial support from Scottish Enterprise, Scotland UnLimited, Edinburgh University Pre-Incubation Scheme, Technology Strategy Board, KTN Biosciences, Genecom, the Edinburgh Design & Technology Centre, and UKTI.

Alongside its work on ticks and Lyme disease, Xeroshield is currently working on the development of a textile for use in malaria control and crop protection and a dengue vector control device.

## Introduction

### *What is Lyme disease and how is it transmitted?*

Lyme borreliosis is a disease transmitted to people and animals through tick bites. The disease is transmitted when an infected tick attaches itself to the skin of a host to feed on the host's blood. Ticks (Fig. 1) bite a wide variety of animals, including humans and pets like dogs and cats. They are increasingly prevalent throughout Scotland and are usually found in wooded areas, or associated with heather and bracken.



Fig. 1 Tick (*Ixodes ricinus*)

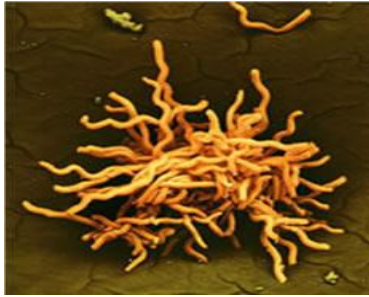


Fig. 2 *Borrelia* spirochetes

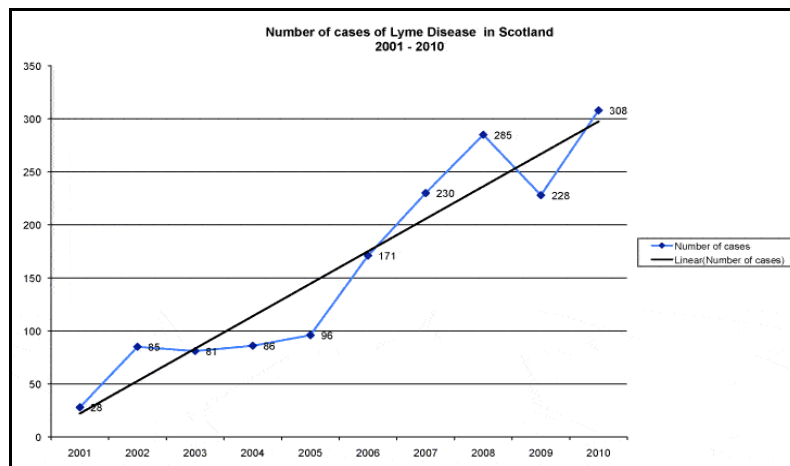


Fig. 3 Bullseye rash

Lyme disease is relatively easy to cure if detected early; a short course of oral therapy with doxycycline is usually effective. However, diagnosis and treatment are extremely difficult once *Borrelia burgdorferi* (Fig. 2), the spirochete causing Lyme disease, enters the nervous system. In the later stages Lyme disease can produce a wide variety of neurological, immunological and psychiatric symptoms.

## Is Lyme disease a major risk in Scotland?

Lyme disease is an increasing problem in the UK, with approximately 2000 confirmed cases each year and an 11-fold increase in the number of cases in Scotland during the last decade, from 28 in 2001 to 308 in 2010<sup>1</sup>. This increase is probably due to environmental factors<sup>2</sup>, although a rise in popularity of outdoor pursuits such as hillwalking and mountain biking has also increased the number of individuals entering habitats with large tick populations. At the same time, these figures are likely to be masking a much larger problem.



Conducted by Dr Dave Ashcroft between 2007 and 2010, an audit of patients at the Aberfeldy and Kinloch Rannoch Medical Practice assessed the prevalence of Lyme disease amongst the local population. The audit identified 23 confirmed cases of the disease out of a total population of 4,600, equivalent to an incidence ratio of 125 cases per 100,000<sup>3</sup>. This is considerably higher than previous estimates for Scotland as a whole, which had indicated an overall Lyme borreliosis incidence of 5.9 per 100,000<sup>4</sup>. Extrapolated to the Scottish population as a whole, the Aberfeldy and Kinloch Rannoch Medical Practice Lyme disease Audit suggests there could be as many as 6,500 people across Scotland suffering from Lyme disease each year. It also indicates how many cases of the disease may be going undiagnosed and untreated because the population is not being systematically audited for the disease, as was the case in the Aberfeldy study.

The increasing prevalence of the disease can be explained by a number of factors. Firstly, high participation in leisure activities which take place in Scotland's great outdoors, such as hillwalking and mountain biking, is exposing an increasing number of Scots to the risk of infection. In 2011, for example, Scottish adults made around 360 million visits to the outdoors for leisure and recreation<sup>5</sup>. Those working in outdoor rural occupations such as sheep farming, gamekeeping and forestry groups are also at high risk of exposure to tick bites and Lyme disease.

<sup>1</sup> Scotland.gov.uk (2010) *Annual Report of the Chief Medical Officer 2010*. [online] Available at: <http://www.scotland.gov.uk/Publications/2011/12/14120931/7>

<sup>2</sup> Ostfeld, R (2011) *Lyme Disease: The Ecology of a Complex System*. Oxford University Press. 216pp.

<sup>3</sup> Ashcroft, D (2011) *JLA Awareness Day*. [online] Available at: <http://www.lymediseaseaction.org.uk/wp-content/uploads/2011/08/TaysidePerspectiveLymeTalk.pdf>

<sup>4</sup> Ashcroft, D (2011) *JLA Awareness Day*. [online] Available at: <http://www.lymediseaseaction.org.uk/wp-content/uploads/2011/08/TaysidePerspectiveLymeTalk.pdf>

<sup>5</sup> snh.gov.uk (2011) *Scottish Recreational Survey 2011*. [online] Available at: <http://www.snh.gov.uk/docs/B1075212.pdf>

Recent research suggests pets are also at increasing risk of contracting Lyme disease from ticks. A report by the University of Bristol found that, on average, one in every 200 dogs in the UK is likely to be carrying ticks infected with Lyme disease. With 495,600<sup>6</sup> Scottish households owning a dog, somewhere in the region of 2,500 could be at further risk of contracting Lyme disease from their own pets. Factoring in the risk from cats and other domesticated animals, the potential threat from Lyme disease is extensive.

The Annual Report of Scotland’s Chief Medical Officer 2010, published in December 2011, highlights the growing danger of Lyme disease in Scotland. The report states:

*“One concerning trend in zoonoses, i.e. diseases that can be transmitted from animals to humans, is that shown by the increase in Lyme disease, a tick-borne disorder. The rise cannot be accounted for purely by changes in laboratory protocols or in the number or demographics of patients tested. Variations in climatic conditions and alterations in clinical presentations may have contributed to this continuing rise year on year. This is also likely to be impacted by improved recognition and clinical suspicion”<sup>7</sup>.*

Based on the figures shown in Table 1, a UK prevalence of 125 per 100 000 (as suggested by prominent UK charity Lyme Disease Action) would be similar to that of many other countries with better monitoring.

**Table 1: Lyme borreliosis in 12 European countries and 13 US states with highest prevalence of the disease (also including figures for UK, Scotland alone and Aberfeldy & Kinloch Rannoch Medical Practice)**

Country/US state	Population	No. of LD cases	Confirmed cases per 100 000
<b>North/Central Europe</b>	<b>355 180 000</b>	<b>129 898</b>	<b>37</b>
Austria	8 429 000	24 000	285
Czech Republic	10 566 000	3 500	33
Finland	5 403 000	1 400	26
France	63 450 000	10 000	16
Germany	81 991 000	20 000	24
Hungary	9 950 000	20 000	201
Lithuania	3 292 000	1 300	39
Netherlands	16 714 000	22 230	133
Poland	38 317 000	9159	24
Slovenia	2 040 000	2 000	98
Sweden	9 495 000	10 000	105
Switzerland	7 734 000	2 000	26
United Kingdom	62 798 000	2 000	3
Scotland	5 254 800	308	6
Aberfeldy	4 600	23	125
<b>USA</b>	<b>79 604 939</b>	<b>21 389</b>	<b>27</b>
Connecticut	3 580 709	2 004	56
Delaware	907 135	767	85
Maine	1 328 188	801	61
Maryland	5 828 289	938	16
Massachusetts	6 587 536	1 801	27
Minnesota	5 344 861	939	18
New Hampshire	1 318 194	887	67
New Jersey	8 821 155	3 398	39
New York	19 378 102	3 118	16
Pennsylvania	12 702 399	4 739	37
Virginia	8 096 604	756	9
Wisconsin	5 711 767	1 241	22

<sup>6</sup> Pfma.org.uk (2010) *Regional Pet Population - PFMA*. [online] Available at: <http://www.pfma.org.uk/regional-pet-population/>

<sup>7</sup> Scotland.gov.uk (2010) *Annual Report of the Chief Medical Officer 2010*. [online] Available at: <http://www.scotland.gov.uk/Publications/2011/12/14120931/7>

## *Economic impact of Lyme disease*

Due to the limitations of current laboratory methods, diagnosis of Lyme disease has to be based on clinical findings. Since the symptoms of Lyme disease are very diverse, and mimic more common diseases like arthritis and multiple sclerosis, patients suffering from chronic Lyme disease may undergo years of repeated misdiagnosis and ineffective treatment.

In response to a parliamentary question from Alex Fergusson MSP (09/08/12), the Scottish Government admitted that it did not know the cost of Lyme disease to the Scottish economy. The Scottish Government's response simply stated that the information was "not held centrally as NHS boards are not required to report this information." (23/08/12).

Research funded by the European Union and published in 1993 estimated the cost of Lyme disease per patient to be in the region of €40,000<sup>8</sup> (equivalent to about £50,000 today). This calculation includes the costs of diagnosis, treatment and lost working hours. Published in 2003, a more recent study estimated the costs of Lyme disease in Scotland to be in the region of £331,000. However, this is likely to be a significant underestimate, given the number of cases of Lyme disease thought to be going undiagnosed or misdiagnosed each year.

## *How can we tackle Lyme disease?*

Lack of awareness among the general public and GPs has result in underreporting and delays in initiating treatment. Antibiotics can be effective in treating the disease, provided these are administered soon after being bitten by an infected tick. Conversely, failure to diagnose and treat the disease quickly can lead to complications, particularly if the disease enters the nervous system.

Symptoms are very variable and may not be associated with tick bites by the sufferer. A characteristic "bull's-eye" rash (*erythema migrans*) (Fig 3, page 4) is seen in less than half of all infected individuals. Through ignorance of Lyme disease, or because a patient did not mention having been bitten by ticks or having entered a high-risk habitat, doctors may administer incorrect or inadequate treatment. Misdiagnosis means victims of the disease often resort to spending large amounts of their own money seeking a cure<sup>9</sup>.

Where Lyme disease is suspected, diagnosis is generally based on clinical characteristics, most easily identified when these can be associated with a tick bite and/or possible exposure in an area known to be endemic for the disease. Serological tests may be ordered by GPs to provide confirmation. However, although the standard two-tiered system of serology based on measurement of IgG antibodies to *B. burgdorferi* is highly specific, it has low sensitivity in the early weeks of infection and is not recommended for evaluation of patients with erythema migrans<sup>10</sup>.

In a reply to a parliamentary question about prevention by Margaret McDougall MSP, the Scottish Government acknowledged that the key to tackling the disease lay in prevention. It stated (24/07/12) that as there was "*no immunisation against Lyme disease, prevention depends upon key messages to the*

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<sup>8</sup> Hilysens.eu (2011) Hilysens | Web. [online] Available at: <http://www.hilysens.eu/index>

<sup>9</sup> Oksi, J, M Marjamaki, J Nikoskelainen & MK Viljanen. (1999) *Borrelia burgdorferi* detected by culture and PCR in clinical relapse of disseminated Lyme borreliosis. *Annals of Medicine* 31: 225-32.

<sup>10</sup> American Lyme Disease Foundation (2007). *The Laboratory Diagnosis of Lyme Disease II, Emerging Views on Serodiagnosis*. Available at: [http://www.aldf.com/2nd\\_Banbury\\_Conference.html](http://www.aldf.com/2nd_Banbury_Conference.html)

*public who frequent rural areas. These key messages are issued via Health Protection Scotland's Tick Fact Sheet and the Health Protection Agency's seasonal Tick Awareness Week alert, which highlight the importance of preventative measures against tick bites, for those visiting rural areas."*

While these initiatives are welcome, the strategy of placing information online for members of the public to seek out does not appear proactive enough to be genuinely effective. Xeroshield's own public survey found almost two in three people consider the level of information currently available about Lyme disease to be 'inadequate' or 'non-existent'.

Lyme disease as a serious public health problem is a relatively new phenomenon, the causative organism only having been identified in the 1980s<sup>11</sup>. Xeroshield's public survey reveals a poor level of understanding about how to deal with ticks once bitten. As a result of ignorance regarding the dangers of Lyme disease, many people continue to remove ticks by a variety of crude methods that may exacerbate the risk of infection, leaving the mouthparts inside the skin and/or compressing the tick and causing it to regurgitate infected saliva into the bloodstream. These methods include using the fingers or tweezers and applying some sort of caustic or suffocating agent directly onto the tick, such as alcohol or nail varnish. Although several specialized tick removal tools are available, these also rely on mechanical removal of the animal, leaving the mouthparts in the skin in a high proportion of cases. Thus their effectiveness in actually preventing Lyme disease may be minimal.

In answer to Parliamentary questions tabled by Margaret McDougall MSP, the Scottish Government has confirmed it currently has no plans to commit additional resources towards tackling Lyme disease, despite the concerns raised by Scotland's Chief Medical Officer about the rising number of recorded cases of the disease.

### *How effective are current methods of control?*

Although ticks do not begin to feed immediately once they have attached to a host, it is important that they are removed from the skin as quickly as possible. Although it is generally considered that ticks spend 24 hours attaching before beginning to feed and transmitting *Borrelia*, there is evidence that this is not always the case. A recent study indicates that *Ixodes* ticks that have started to feed but become dislodged are able to transmit *Borrelia* within only 17 hours of attachment to another host. This is because the first feeding triggers the spirochete's migration from the tick's midgut to its salivary glands. By the time the tick has reattached, the bacteria may already be in the salivary glands and ready to enter the host.

While current tick removal devices are quick to use, a major evaluation of these devices conducted in 2006<sup>12</sup> found that even the most effective ones available on the market only removed the entire tick in 20-30% of cases, leaving the host exposed to infection. Current mechanical devices are also likely to stress the tick during the removal process and increase the risk of infected saliva being regurgitated by the tick into the host's bloodstream, thereby passing on infection.

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<sup>11</sup> Burgdorfer W, AG Barbour, SF Hayes, JL Benach, E Grunwaldt & JP Davis (1982) Lyme disease – a tick-borne spirochetosis. *Science* 216: 1317-9

<sup>12</sup> Zenner, L., E. Drevon-Gaillot & M.P. Callait-Cardinal (2006) Evaluation of four manual tick-removal devices for dogs and cats. *The Veterinary Record*, October 14, 2006.



According to Vanderhoof-Forschner<sup>13</sup> 13% of European ticks are systemically infected and could therefore transmit *Borrelia* within 24 hours. After the tick is removed it is important to find out whether the tick was carrying Lyme disease. Several laboratories in Europe and North America offer *Borrelia* detection services, based on real-time PCR which are much more sensitive and specific than serological testing<sup>14</sup>. However these still require the client to remove, immobilize, package and send the tick to the testing centre, a complex and disagreeable process for many people. At least one self-use kit is also on the market<sup>15</sup>, based on a similar principle (lateral flow) to those used for pregnancy testing. However this requires the user to macerate the tick prior to testing, which carries the risk of accidental infection through cuts or mucous membranes.

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<sup>13</sup> Vanderhoof-Forschner K. (2003) *Everything You Need to Know about Lyme Disease and Other Tick-Borne Disorders*. John Wiley & Son, Hoboken NJ.

<sup>14</sup> For example Clongen Inc. of Germantown MD in the United States, [www.clongen.com/](http://www.clongen.com/)

<sup>15</sup> Care Plus® Tick-Test - Lyme borreliose, [www.careplus.eu/en/first-aid/tick-test](http://www.careplus.eu/en/first-aid/tick-test)

## **Xeroshield's proposals**

Xeroshield is currently working on the development of a tick removal device for humans and pets that we anticipate will be a significant improvement on any of the mechanical devices currently available on the market – both in its effectiveness at removing the entire tick and also in terms of not placing undue stress on the tick during the removal process. Xeroshield plans to combine the device with a laboratory service that would enable ticks collected and immobilised using the device to be sent away and then tested for Lyme disease.

We believe that the ideal scenario for people at risk of contracting Lyme disease and health professionals would be a method of removing ticks with the minimum of manipulation required, allowing the tick to be detached, immobilized and packaged without handling and sent for testing. We therefore propose to develop a robust, user-friendly, multi-use device that was able to detach the tick in its entirety and collect it into an easily-sealed container. Our proposals are then for the tick to be sent to a recognized, accredited testing centre which guaranteed a result in the shortest time possible. This should enable more accurate and rapid diagnosis and treatment of people with Lyme disease.

The device would be marketed with labelled packaging that provided instructions on where to send the sample, pre-pay for the analysis and receive the result. This process would be safer and more seamless than any of the alternatives currently available. Results would be sent to a central database, providing valuable information on the incidence of Lyme disease throughout Scotland and the UK in general. Given that Lyme disease now occurs throughout northern Europe and North America, the potential market for the device and service is considerable. However, for the purpose of the present study we attempted to understand the potential market in Scotland.

Xeroshield recently submitted its final report to the UK Technology Strategy Board and is now seeking private- and public-sector funding to develop a prototype of the tick removal device and a viable business case for the associated laboratory testing service. The roll-out of this device and service has the potential to provide a valuable public service by generating a suitably representative sample to enable the percentage of ticks infected with Lyme disease in Scotland to be accurately estimated. This information is crucially important for the Scottish Government and Health Protection Scotland to be in a position to develop a properly effective strategy for tackling the disease and preventing its spread.

Xeroshield's proposals also offer important opportunities for the technology to be patented and developed in Scotland and to be exported throughout Europe and North America – as well as to other countries worldwide, where ticks are responsible for spreading other life-threatening diseases.

## **Purpose and scope of the study**

Xeroshield successfully secured funding from the UK Technology Strategy Board to undertake a proof of market study to assess the extent to which there would be a ready market in Scotland for the integrated tick removal device and laboratory testing service it is hoping to develop.

The study can be broken down into three phases:

**Phase 1, March – September 2012:** Online / face-to-face survey questionnaire – 1,000 completed surveys

**Phase 2, June - September 2012:** Semi-structured interviews and case histories

**Phase 3, September – October 2012:** Focus group discussions

A final study report was submitted to the UK Technology Strategy Board upon successful completion of Phase 3 of the study.

## **Results of semi-structured interviews and focus group discussions**

Those participating in semi-structured interviews and focus group discussions were all individuals with a greater than average knowledge of ticks, in many cases highly concerned about contracting Lyme disease, often through having the disease themselves or knowing someone who had suffered from it. However even the most aware people knew little about the dangers of incomplete removal of ticks, believing it was most important to detach the body of the tick and assuming that in most cases doing so would remove the entire animal. People who had long experience of working or carrying out recreational activities in tick habitat felt competent in twisting ticks off with their fingers. Although the o'tom tick twister was often mentioned as the best device available on the market, it was not considered ideal, especially for removing the smallest ticks (nymphs being mentioned on several occasions although larvae or "seed ticks" are even smaller and might have been the stage referred to).

The respondents were in general receptive to the idea of a new type of tick removal device. When asked what characteristics such a device should have they replied "reliable", "simple", robust" "durable", "relatively cheap" and "able to remove all of even the smallest ticks", without stressing them and causing them to regurgitate infected saliva into the bloodstream. They felt the device should be easy to use, lightweight, small enough to fit into the pocket and easy to clean (sterilise). It should be "something easy to find (purchase in retail outlets)" and come with clear instructions for use. One interviewee pointed out the problem older people had in removing ticks due to deteriorating eyesight, and another suggested developing slightly different models for pets and humans. The latter could be something included in first aid kits.

With regard to the service, the amount people would be willing to pay varied from a few pounds to about £30, £50 being viewed as too expensive. In general it was viewed as useful and preferable to waiting for Lyme disease symptoms to appear. Cost was the main limitation mentioned, although accuracy and the possible inconvenience of sending off a sample were also cited.

## **Summary of Lyme disease case histories**

Five of the individuals contributing detailed case histories to the study contracted Lyme disease through recreational activities and two through their occupations. Another believed that she had been bitten by a tick brought into her home by a working dog that was infested. Three of them removed the ticks themselves and might have avoided contracting the disease or accessed more rapid, accurate treatment if the proposed device/service had been available to them. One of these was only able to remove part of the tick and visited a nurse who extracted the rest of the animal from her skin. This process is likely to have increased the chance of transmission if the tick had not already passed on the infection.

All patients interviewed had to undergo months or even years of misdiagnoses and unnecessary tests and at least half of them could have benefited from the technology Xeroshield hopes to develop. They each cost the NHS tens of thousands of pounds in treatment, lost hundreds of work days and had to seek private medical care none of them could easily afford.

## Survey of General Practitioners

A dedicated survey was circulated to general practitioners resulting in a total of 70 completing it online.

Given the dissatisfaction towards the medical profession expressed by members of the public in other sections of the study, the level of cooperation received from GPs in the Highland and Forth Valley regions was unexpectedly good. The results were also encouraging for our study, with only about half of the respondents owning a specialized device to remove ticks and only a third having experience of using it to remove ticks (tweezers being used much more frequently). However they each reported having removed an average of 3-4 ticks from patients in the last year, taking into account that in over 80% of cases the tick had already dropped off or been removed by the patient before he/she arrived at the surgery. The total number of cases seen by GPs in the survey was 332, a 10% increase compared to the total number of confirmed cases of Lyme disease reported throughout Scotland in the previous year and further indication of the increasing prevalence of the disease. Over 10% of these cases were seen by a single practice.

Most importantly for the present study, 84.7% of doctors said they would use an accredited service based on detection of *Borrelia* in a tick and 88.1% would accept the result if brought to them by a patient who had used the service.

## Summary of responses: GP Survey

QUESTION	ANSWERS				
1. Do you use a specialized tick remover in practice?	Yes		No		
	44.9		55.1		
2. Is it practice policy to use a specialized tick remover to remove ticks from patients?	Yes	No	Don't know		
	27.1	64.3	8.6		
3. Where did you get your current tick remover? A - don't have one; B - medical supplier; C - chemist; D - don't know	A	B	C	D	
	50.0	7.4	29.4	13.2	
4. How effective do you find current methods of removing ticks from patients? A - very effective; B - effective; C - not very effective; D - poor	A	B	C	D	
	24.1	34.5	29.3	12.1	
5. How many patients have you removed ticks from in the past year?	Mean 3.4, range 0 – 25				
6. How many patients have you treated for Lyme disease in the past year?	Mean 4.7, range 0 – 35				
7. If there was an accredited service that allowed you to know within a few days whether a tick was infected would you use it?	Yes		No		
	84.7		15.3		
8. If a patient who had been bitten by a tick came to you with a positive test result from that this service would it influence your diagnosis?	Yes		No		
	88.1		11.9		
<b>PLEASE ANSWER FOLLOWING QUESTIONS BASED ON YOUR LATEST PATIENT WITH TICK/LD</b>					
9. Was the tick still attached at the time of appointment?	Yes	No	No idea		
	13.8	81.5	4.6		
10. If not, did the patient mention how quickly after attachment the tick had dropped off?	Yes	No	No idea		
	42.4	42.4	15.3		
11. Did you advise the patient to remove the tick before coming to the appointment?	Yes		No		
	8.5		91.5		
12. During the appointment, did you remove the tick? If so, by what method? A - yes, with tweezers; B - yes, with fingers; C- yes, with special tick remover; D - yes, using other method; E - no	A	B	C	D	E
	12.3	0	7.0	0	80.7
13. Do you take blood sample if you suspect Lyme disease?	Yes		No		
	87.3		12.7		
14. Would you prescribe antibiotics BEFORE testing blood sample? A - wouldn't prescribe any antibiotic before testing B - would prescribe before, if appropriate	Yes		No		
	85.7		14.3		
15. Would you prescribe antibiotics AFTER testing blood sample?	Yes	No	Sometimes		
	45.6	5.3	49.1		
16. What antibiotic would you normally choose to treat Lyme disease? A - doxycycline; B - amoxicillin; C - ceftriaxone; D - other (please specify)	A	B	C	D	
	90.8	7.7	1.5	0	
	Other- N/A				
17. Would you provide the patient with any information about Lyme disease?	Yes		No		
	89.1		10.9		
18. If so, where would you get this from? A - leaflets; B - online bulletins; C- Health Protection Scotland; D - other source (please specify)	A	B	C	D	
	43.9	31.6	5.3	19.3	
	Various, esp. patient .co.uk				
19. Have you ever referred a patient with Lyme disease to a specialist (e.g. infectious diseases consultant)?	Yes		No		
	40.9		59.1		
20. Do you follow up patients to see if they have developed any other symptoms?	Yes		No		
	39.3		60.7		

## Survey of Veterinarians

A separate survey was also circulated to veterinary practitioners throughout Scotland.

Results for the veterinary questionnaire contrasted markedly with those obtained for GPs. Responses were obtained from about 10% of all practices throughout Scotland, including practices based in Glasgow, Sutherland, Caithness, the Western Isles, Aberdeen and NE Scotland, Dundee, Moray, Argyll and Bute, SW Scotland, West Lothian and Edinburgh.

Although two-thirds of veterinarians often removed ticks from their animal patients, most of them (77.0%) considered Lyme disease to be only a “minor” risk to their patients. They rarely found ticks on themselves. The overwhelming preference was for a specialized tick removal tool and all the respondents who owned one used an o’tom tick twister. They were very happy with the effectiveness of this device and 62.5% saw no need for another, particularly if it was more expensive. None of the veterinarians surveyed would pay more than £20 for such a device. This seems to indicate that there is no market among veterinary surgeons for our technology, perhaps because they are less concerned about removing the entire tick from a patient and are much less concerned about Lyme disease, even in terms of their own safety and wellbeing.

However there was more interest in the proposed service, with 84.6% of respondents saying they at least might pay for it, depending on the cost. Unlike NHS physicians, veterinarians would of course be able to pass this cost on to the client. Given that our technology is based on the device linked with the service, this means that the former still has the potential to be marketed to veterinarians.

### Summary of responses: Veterinarian survey

Questions	Answers							
1. Where do you practice?	Throughout Scotland							
2. Type of animal work carried out and how divided up (median percentage for all respondents): A - dogs; B - cats; C - small animals; D - horses; E - cattle; F - sheep; G - poultry; H - zoo animals	A	B	C	D	E	F	G	H
	31.40	21.30	0.10	0.10	11.20	0.10	0.10	0.10
3. How often do you remove ticks from animal patients?	Often		Sometimes			Rarely		
	66.7		25.9			8.3		
4. What method do you use? A - fingers; B - alcohol or other agent applied to tick; C - tweezers; D tick removal tool. If D, please list any tools used	A		B		C		D	
	20.8		8.3		0		87.5	
	All D responded O’tom tick twister							
5. How often do you remove ticks from yourself?	Often		Sometimes			Rarely		
	4.2		16.7			79.2		
6. What method do you use? A - fingers; B – alcohol or other agent applied to tick; C - tweezers; D tick removal tool. If D please list any tools used	A		B		C		D	
	27.8		5.6		5.6		72.2	
	All D responded O’tom tick twister							
7. How seriously do you take Lyme disease as a risk to your animal patients? A - very serious; B - serious; C - minor risk; D - no risk at all	A		B		C		D	
	0		23.0		77.0		0	
8. How effective do you find technologies currently available to remove ticks? A - very effective; B - effective; C - not very effective; D - poor	A		B		C		D	
	55.5		40.1		0		3.7	
9. How much would you pay for device guaranteed to remove entire tick? A - 0, existing devices fine; B - <£10; C - <£20; D - <£30; E - <£40; F - <£50; G - £50+	A	B	C	D	E	F	G	
	66.7	29.6	3.7	0	0	0	0	
10. Would you pay for service to test if ticks were infected? A - yes; B - depends on cost; C - no.	A		B			C		
	11.5		73.1			15.4		

## **Public Survey**

### *Overview*

As part of the proof of market study, Xeroshield undertook a survey asking members of the public a series of questions about their own experience of ticks and Lyme disease. The survey was also designed to measure the level of potential public interest in the technology Xeroshield is seeking to develop.

### *Promotion of the survey*

The survey, which attracted over 1,100 responses, was held between March and September 2012 and contained seventeen questions on the subject of ticks and Lyme disease. Participation in the survey was promoted through a number of sources, including media coverage in the Press and Journal, the Herald, the Hebrides News, the Deeside and Donside Piper, the Scottish Daily Express, the Scottish Daily Mail, the Courier and Advertiser, the Sunday Express Scotland, and the Scotsman.

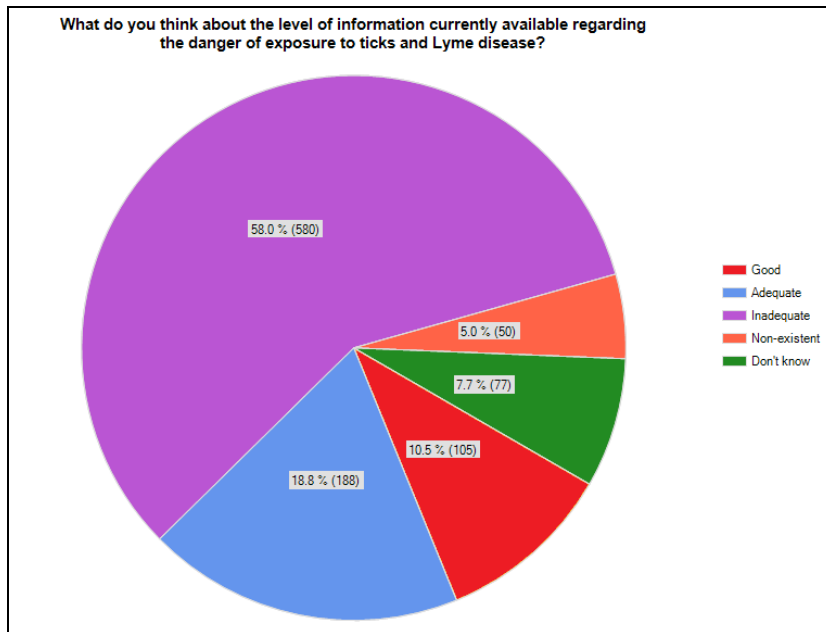
The survey was also promoted through online publications, newsletter articles, and mailings by a wide range of organisations including the Duke of Edinburgh Award Scheme, Scottish Orienteering, BADA-UK, Ramblers Scotland, Forestry Commission Scotland, Scottish Association for Country Sports, Scottish Gamekeepers Association, Friends of the Pentlands, the British Association for Shooting and Conservation, Scottish Cycling, the Grampian Mountaineering Council, the Royal College of General Practitioners in Scotland, and the Scottish Countryside Rangers Association.

Participation in the survey was also encouraged through specialist online forums including: Argyll Communities, Lyme Aware, The Heather Trust, the National Rural Network, the Gundog Training Forum, Cryptozoology Online and the Caithness Business Index.



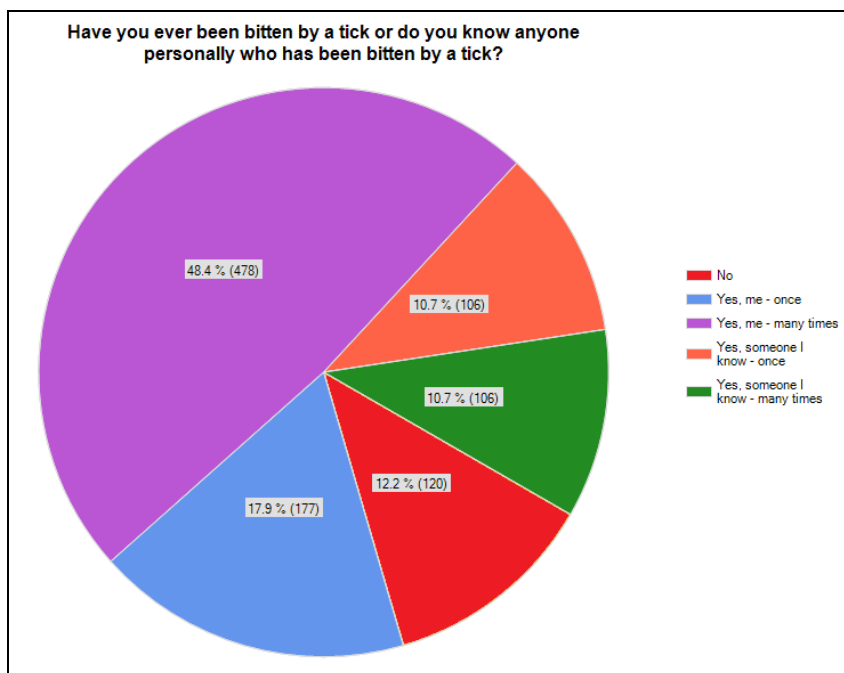
## Summary of findings

### Public information about ticks and Lyme disease



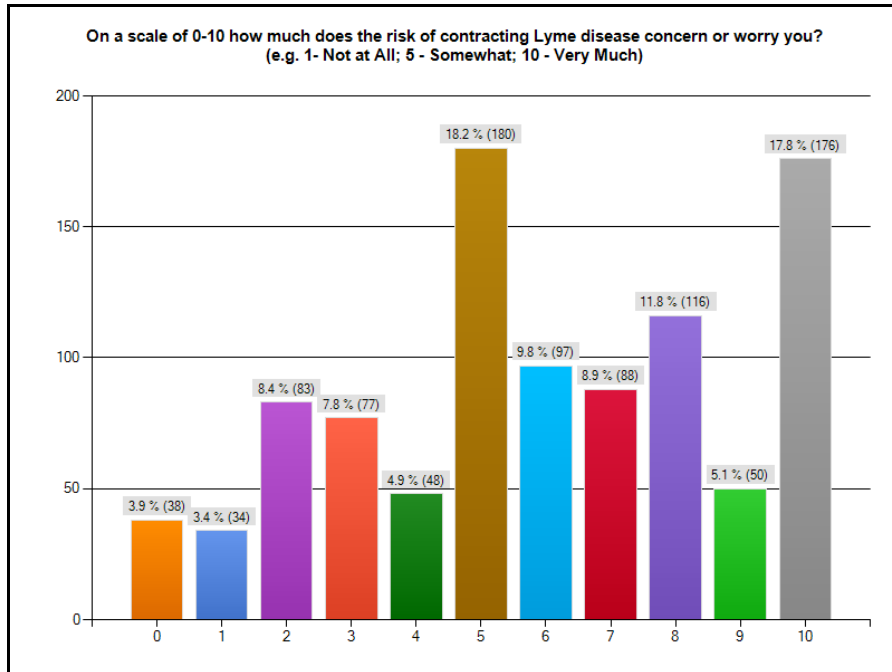
A majority of respondents to the survey (58.0%) thought the level of information currently available regarding the danger of exposure to ticks and Lyme disease was 'inadequate'. A further 5% thought public information currently available was 'non-existent'. By comparison, only 10.5% thought that the level of information was 'good', 18.8% thought information levels were 'adequate' and 7.6% did not know.

### Experience of tick bites



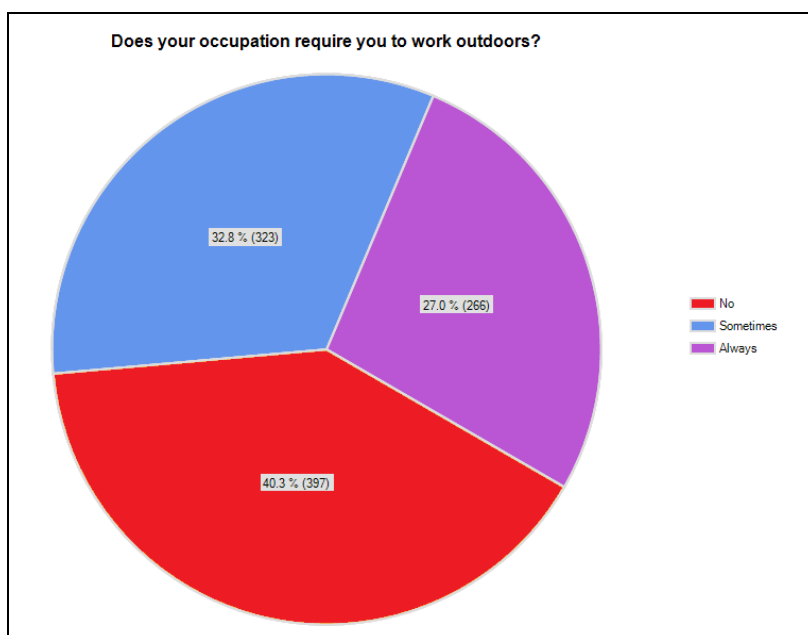
In all 48.4% of people said they had been bitten by ticks ‘many times’ while 87.7% of respondents had either been bitten by a tick themselves or knew someone who had. Only 12.2% did not know anyone who had been bitten by a tick.

### Concern about the risk of Lyme disease

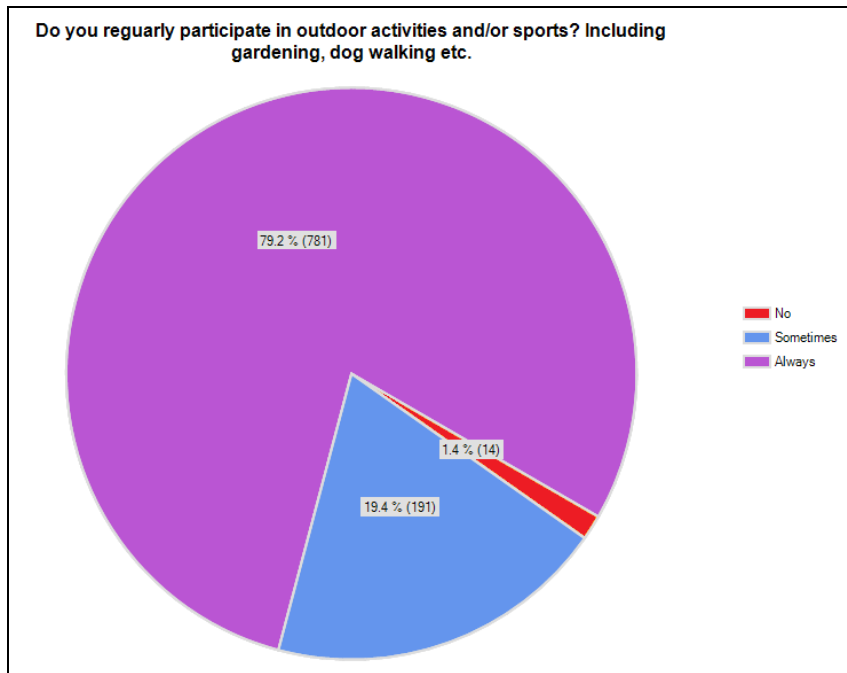


On a scale from 1 (not at all) to 10 (very much), the survey found that 71.6% of individuals rated their level of concern about Lyme disease as at least “somewhat”. Those who answered 10 (very much concerned about contracting Lyme disease) made up 17.8% of responses. Only 3.4% of individual were ‘not at all’ concerned (rating 1).

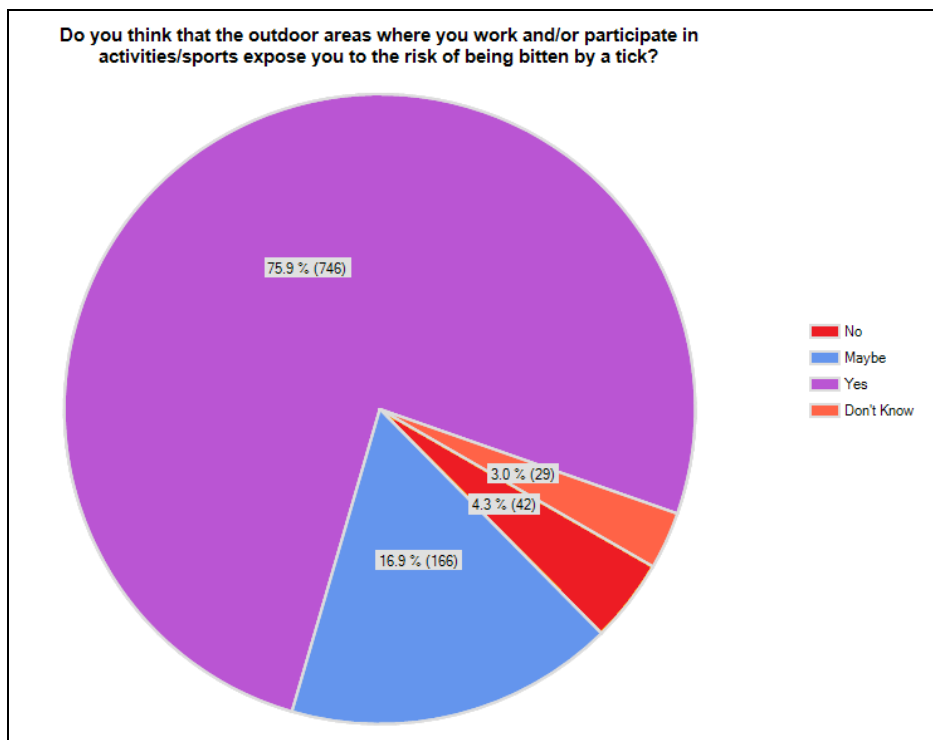
### Participation in outdoor activities



In all 59.8% of respondents had occupations that required them to work outdoors either some or all of the time.

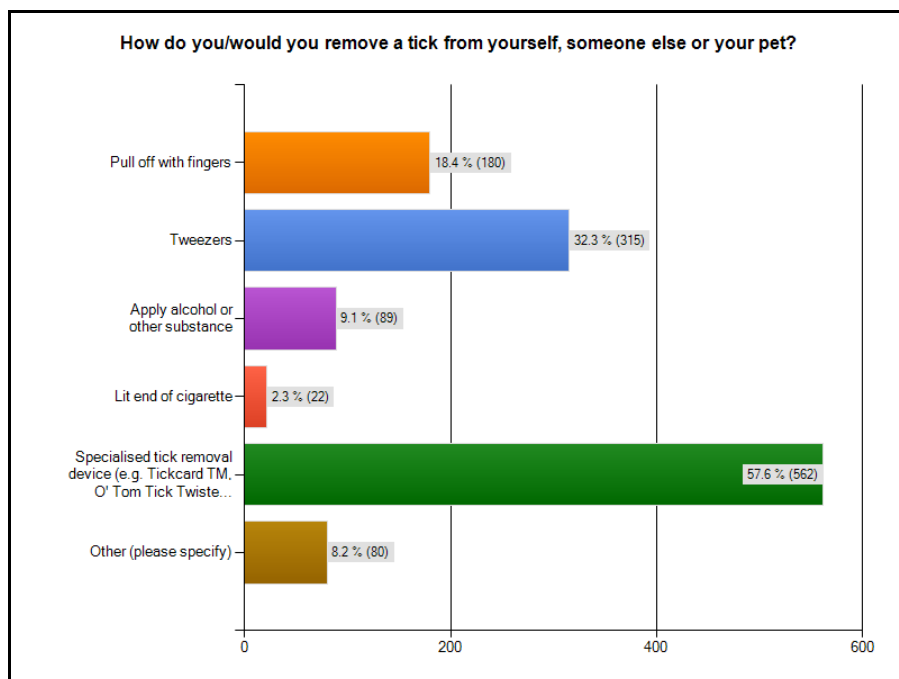


In all 98.6% of people responding to the survey 'sometimes' or 'always' engaged in outdoor leisure activities.



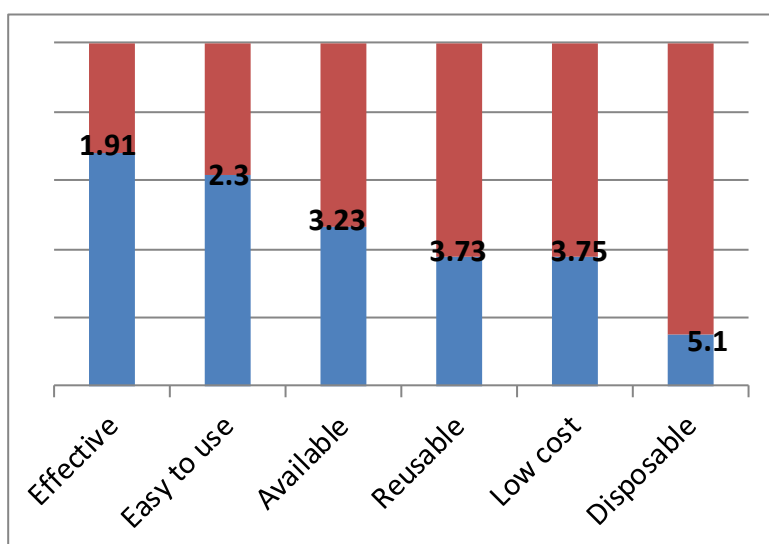
In all 75.9% of people answering the question were definite that participating in outdoor work or leisure activities exposed them to risk of being bitten by ticks. A further 16.9% felt there may be a risk of being bitten by ticks from these activities.

## Methods of tick removal



When asked how they would remove ticks if they were bitten, 18.5% of respondents answered that they would pull off ticks with their fingers. Almost three fifths (57%) stated that they would use a specialised tick removal device while 32.3% would use tweezers and 9.1% would apply alcohol or some other substance to their skin.

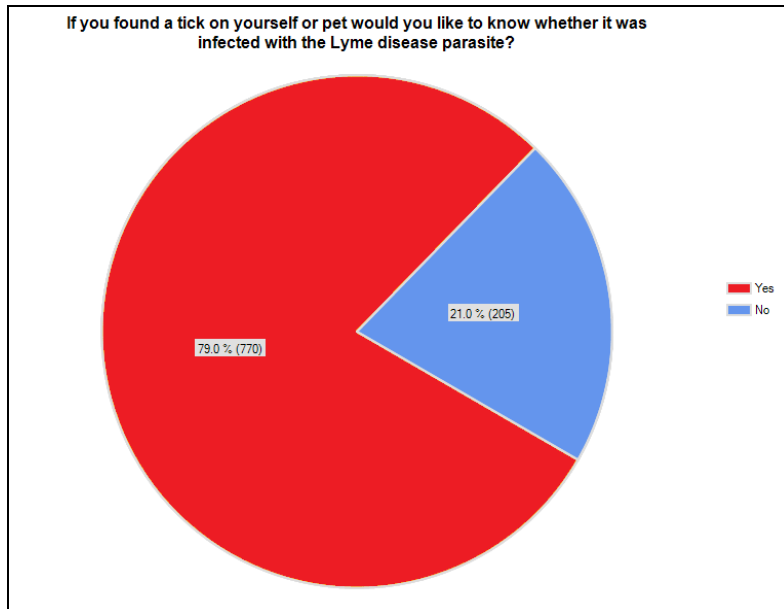
## Characteristics of a tick removal device



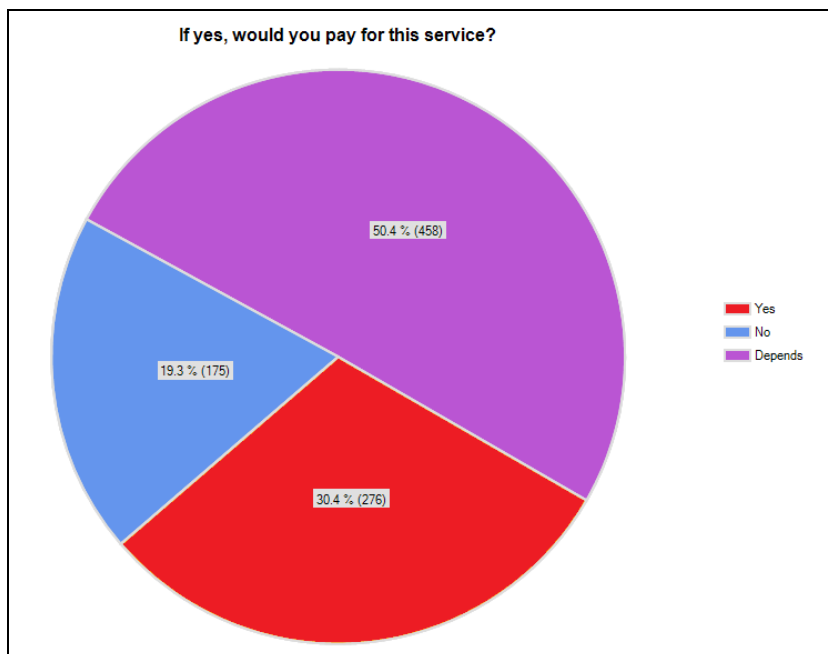
Average importance rating (1 = very important to 6 = not very important)

When asked to choose what respondents thought should be the main characteristics of a tick removal device, effectiveness scored the highest rating, followed by ease of use. Cost and disposability were rated lowest in the order of priorities.

### Laboratory testing service



In all 79% of respondents said they would be interested in knowing whether a tick that had bitten them or their pet was infected with *Borrelia*.



When asked whether they would pay for a laboratory testing service to determine whether a tick having bitten them or their pet was infected with Lyme disease, 30.4% stated they would, while a further 50.4% would consider paying depending on cost and other factors. Only 19.3% stated that they would not be willing to pay for this service.

When asked why they would not pay, the two most common answers were that this service should be publically available on the NHS, and that it would cost too much.

An answer sample is included below.

*"it could be quite costly for me - I get lots of bites!"*

*"Why would it not be on the NHS? If it was relatively inexpensive I would possibly pay for it"*

*"tick should be sent to NHS laboratory for testing"*

*"500 tests, I don't think so, government should do sample tick testing?"*

*"Happy in my ignorance [sic]. I have been pulling ticks out of myself, child [sic] and dog for years. I'm well aware that as i life in Scotland and walk through areas where both sheep and deer inhabit then we will be exposed to ticks. They reckon it's only the ticks from deer that we need to worry about."*

*"Depends what it could offer. Eg. Does it increase my chance of early detection of disease so greater chance of treatment/less complications due to early detection - if so, yes I would pay. If knowing this makes little difference to diagnosis & treatment if contracted from the tick then no. Guess I don't know enough about this potential service."*

*"For me or child - yes £20-£30 For dog - probably not, he gets lots of them!"*

## Report Conclusions

The survey, case studies and wider research undertaken by Xeroshield provide extensive evidence to suggest:

1. That Lyme disease is a potentially serious long-term condition if not treated quickly;
2. That recorded cases in Scotland are increasing year-on-year as is the associated economic cost of diagnosis, treatment and lost working days;
3. That many more cases of the disease than those recorded are likely to be going undiagnosed or misdiagnosed, and improperly treated or untreated;
4. That an increasing number of Scots are at risk of exposure to tick bites and Lyme disease due to regular participation in outdoor activities and a range of other factors contributing to a growing tick population;
5. That public information currently available about ticks and Lyme disease is inadequate;
6. That the current best available methods for removing ticks are far from 100% effective and many people are still resorting to ineffective or counterproductive methods for removing ticks;
7. That there would be a strong interest from the public – particularly those at high risk of exposure to ticks – in paying for a more effective device for removing ticks, coupled with a laboratory service to test ticks immobilised using this device for the Lyme disease organism;
8. That this technology would offer a number of important public health benefits including:
  - a. More effective tick removal leading to reduced risk of infection;
  - b. Rapid testing of removed ticks for the Lyme disease organism, enabling quicker and more accurate diagnosis and treatment;
  - c. Creation of a suitable test sample of ticks to enable an accurate estimate of the percentage of ticks in Scotland that are carrying Lyme disease and the geographical spread of the disease;
9. That the technology would also offer a number of important economic benefits including:
  - a. Reducing the significant long-term cost of Lyme disease to the Scottish economy by ensuring rapid treatment and thereby reducing the number of chronic cases of the disease;
  - b. Opportunities for the technology to be patented and developed in Scotland and subsequently to be exported across Europe and North America – as well as to other countries worldwide that are affected by life-threatening tick-borne diseases.

## **Acknowledgements**

In undertaking its study, Xeroshield gratefully acknowledges the help and cooperation of the following:

- The Forestry Commission Scotland
- Ramblers Scotland
- Grampian Mountaineering Council
- Scottish Gamekeepers Association
- Scottish Association of Country Sports
- Friends of the Pentlands
- Scottish Orienteering
- Scottish Countryside Rangers Association
- Duke of Edinburgh Awards Scheme
- Scottish Cycling
- British Association for Shooting and Conservation
- Royal College of General Practitioners Scotland
- Royal (Dick) School of Veterinary Studies
- Lyme Disease Action
- BADA UK
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- Individual members of the public who completed our ticks and Lyme disease survey
- Individual members of the public who contributed anonymous case studies of their own experience of dealing with Lyme disease