Ticks, mammals and birds
- Ecology of ticks & *B. burgdorferi*

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Overview of presentation

Ticks

• Introduction to the British tick fauna
• Focus on *Ixodes ricinus* – the sheep/deer tick
• Tick surveillance at a national scale
• Tick mapping at a landscape scale – national parks/AONBs
• Tick mapping at a habitat scale – impact of woodland management
• Tick mapping in urban areas

Mammals & birds

• Understanding the ecology of Lyme borrelia in ticks and role of wildlife
The British tick fauna

22 species recorded
19 Hard ticks (Ixodid)
• 15 *Ixodes* species
• *Dermacentor reticulatus*
• *Haemaphysalis punctata*
• *Hyalomma marginatum* – (imported by migrant birds)
• *Rhipicephalus sanguineus* (imported by pets, not native)

3 Soft ticks (Argasid)
• 2 *Argas/Carios*
• 1 *Ornithodoros* – rarely imported on seabirds
Hard ticks (Ixodid ticks)

• Live outdoors, some are nidiculous (i.e. nest-dwelling); arduous lifestyle, require a chance meeting with animals.

• Once attached, they engorge slowly, dispersed by their hosts long distances on migratory birds.

• Spend most of their time ‘questing’ for blood hosts and attached to their hosts – high mortality rates due to host grooming, predation and environmental factors.

• Hard sclerotised plate (scutum), forward-projecting capitulum.

• Except in male, all stages have a small scutum to allow them to engorge.

• In the male the scutum completely covers its body. It does not engorge. It has armoured plates, to retain moisture levels.
Ixodes – specialist parasites of wildlife

7 species are principally bird ticks:

- **Ixodes arboricola**
  Tree-hole nesting birds

- **Ixodes caledonicus**
  Cliff nesting birds

- **Ixodes frontalis**
  Passerine birds

- **Ixodes lividus**
  Sand martins

- **Ixodes rothschildi**
  Burrow nesting birds

- **Ixodes unicavatus**
  Coastal birds

- **Ixodes uriae**
  Cliff colony birds

Humans are rarely bitten, only as accidental hosts.
Ixodes – specialist parasites of wildlife

6 species are principally mammal ticks:

- **Ixodes acuminatus**
  Small mammals
- **Ixodes apronophorus**
  Wetland mammals
- **Ixodes canisuga**
  Fox tick
- **Ixodes ventralloi**
  Rabbit tick
- **Ixodes trianguliceps**
  Burrowing small mammals
- **Ixodes vespertilionis**
  Horseshoe bats

Humans are rarely bitten, only as accidental hosts.
Ixodes – parasites of humans

2 species are mammal ticks but do bite humans:

Ixodes ricinus
Deer/Sheep/Pasture/Caster bean tick

Ixodes hexagonus
Hedgehog tick

Humans are occasional hosts

Humans are frequent hosts
Hedgehog tick, *Ixodes hexagonus*
Unusual & Imported ticks

Importation of non-native ticks & EU policy

Rhipicephalus sanguineus

Hyalomma marginatum

Monitoring for ticks on migratory birds

970 birds sampled, 7% infested, 21% *Hyalomma marginatum*

Wheatear, whitethroat, Sedge warbler, Redstart
Ixodes ricinus (Deer/sheep tick)

- Larva: 3 pairs of legs
- Male: scutum covers entire body
- Nymph and Female are similar – female much larger with genital aperture and porose area
- Adult male
- Adult female: 3.3mm long
Nationwide tick surveillance

~8000 ticks since 2005 from TRS
Public, GPs, Vets, Wildlife charities
Further 10,000 ticks from field studies

Advice to public on tick bites
Advice on managing ticks in gardens
Tick awareness material
Tick identification to public, GPs and Vets
Raising public awareness of ticks

How to come into contact with ticks?
Ticks don’t jump or fly, but wait until an animal or person brushes past to climb on. They then bite to attach to the skin and start to feed on the blood. It may take several days to complete their blood meal, before they drop off. Ticks can be found throughout the year, but are most active between spring and autumn.

Main health risks
- Ticks can transmit bacteria that cause diseases such as Lyme disease, which can lead to very serious conditions if left untreated. Symptoms of Lyme disease can include a skin rash, fatigue, and muscle and joint pain.
- More serious conditions such as viral-like myalgias, facial palsy, nerve damage and arthritis can develop without treatment, so prevention and early detection are crucial. Lyme disease can be treated with a course of antibiotics.

Perform a tick check
- Make it a habit to check your clothes and your body regularly for ticks when you’re outdoors, and again when you get home. Tick bites may not hurt and you don’t always notice you’ve been bitten, so make sure you thoroughly check yourself, your children and your pets.
- Ticks prefer warm, moist places on your body, especially the groin area, waist, arm pits, behind the knees and along hair lines, so look out for anything as you talk or a speck of dirt. Take simple steps to avoid coming into contact with ticks, such as wearing long-sleeved shirts or pants, avoidance dense vegetation and wearing light-coloured clothing so ticks are easier to spot and brush off. You can also use repellents such as DEET.

Help us record ticks
- PHE monitors changes in tick distribution and investigates the drivers for change. Help us monitor ticks by participating in our nationwide surveillance via the Tick Recording Scheme (TRS). You can send in any ticks you come across, which helps us to update our knowledge of British tick species, that spread across the country and detect unusual species.
- Visit our website for more information on how to take part and download a recording form to post with your specimen. For more information on British ticks or the TRS, please visit our website or email tick@phe.gov.uk

If you have been bitten
- Doing tick awareness by knowing what ticks look like, where they can be found, and practicing prevention bahaviors will help you to avoid tick bites. However, if you do get bitten, washing the tick quickly and correctly can help to reduce any potential risk.
- Remove the tick as soon as possible.
  - The only safe way to remove a tick is to use a pair of forceps or tweezers, or a tick removal tool.
  - Grasp the tick as close to the skin as possible. Pull upwards slowly and firmly, as mouthparts left in the skin can cause a local infection.
  - Once removed, apply antiseptic to the bite area and keep an eye out for several weeks for any changes.
  - Contact your GP if you begin to feel unwell and remember to tell them you were bitten by a tick.

Tick awareness leaflets

209 Tick awareness leaflets

Health Explained: What is Lyme disease?
24 May 2011 Last updated at 23:32
Lyme disease is a bacterial infection transmitted by tick bites. The ticks themselves have to be infected with the bacteria in order to pass it on, and most ticks do not react in the condition, but the UK sees around 3,000 cases a year and the number is on the rise.

Jocelyn Fieldson runs the Health Protection Agency’s tick surveillance and research project from the NHHS Ponton Down laboratory. Her unit has built a collection of around 10,000 specimens collected from all over the UK.

They encourage members of the public to send in any ticks they find themselves or pets after they have been out in the countryside. This information helps to build up a better picture of the current distribution of ticks and where they may be expanding their range.

Jocelyn Fieldson explained to BBC News what Lyme disease is and what symptoms to look out for. He describes how people catch it from ticks, what can be done to prevent getting bitten and how to safely remove a tick.
**Ixodes ricinus distribution**

![Map of Ixodes ricinus distribution in the UK](image)

**Ixodes ricinus**
- PHE Tick Recording Scheme
- BRC Tick Distributions

**2010-2013**

<table>
<thead>
<tr>
<th>Date</th>
<th>Species</th>
<th>Host</th>
<th>Country of Origin</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td><em>Amblyomma sp.</em></td>
<td>Human</td>
<td>Peru</td>
<td>1 Nymph</td>
</tr>
<tr>
<td>2009</td>
<td><em>Hyalomma marginatum</em></td>
<td>Horse</td>
<td>Portugal</td>
<td>1 Male</td>
</tr>
<tr>
<td>2012</td>
<td><em>Ixodes pacificus</em></td>
<td>Human</td>
<td>United States</td>
<td>1 Nymph</td>
</tr>
<tr>
<td>2012</td>
<td><em>Rhipicephalus sanguineus</em></td>
<td>Dog</td>
<td>Greece</td>
<td>2 Males</td>
</tr>
<tr>
<td>2012</td>
<td><em>Rhipicephalus sanguineus</em></td>
<td>Dog</td>
<td>Thailand</td>
<td>3 Males, 3 Females</td>
</tr>
<tr>
<td>2013</td>
<td><em>Ixodes holocyclus</em></td>
<td>Human</td>
<td>Australia</td>
<td>1 Female</td>
</tr>
</tbody>
</table>
Nationwide geo-spatial mapping
Mapping *Ixodes ricinus* at a landscape scale, e.g. national park / AONB

- Delineating regions and sites
- Surveying publicly accessible sites

**Eco/environ variables**
- Predictive variables (landscape)
  - W, SW, SE and E aspects
  - Calcareous & neutral grassland; heathland
  - Impermeable soils
  - Impermeable bedrock & superficial geologies
  - Presence of cattle & sheep grazing
  - Reduced slope
  - High soil moisture
  - Lower midday temperatures

Identifying risk factors

Refining risk

Mapping ticks in an AONB/National Park

Medlock *et al.* 2008

212 Mapping ticks at a regional scale
Mapping *Ixodes ricinus* at a habitat scale - implications for woodland management

1. Management that promotes sunny south-facing rides promote nymph activity
2. Additional ride management is recommended in these locations
3. Regular mowing (and raking) of 1m path-side strip in spring should:
   a. Keep nymph activity down
   b. Reduce public exposure
   c. Benefit rare herb growth and bare-soil invertebrates
4. Mat/mulch management – raking/stacking of leaf litter
   a. Limits survival of ticks
   b. Promotes biodiversity – reptiles, herbs, invertebrates
5. Scalloped edges in bramble areas
6. Spot treatment with bracken herbicide in hot-spots

Figure 2: Schematic depiction of ride management strategies (after Warren & Fuller, 1993)
Impact of habitat corridors on *Ixodes ricinus* - the role of field margins as habitats for ticks

![Image showing research activity in a field](image)

<table>
<thead>
<tr>
<th>Habitat Type</th>
<th>Mean Abundance per 100m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood</td>
<td>0.5</td>
</tr>
<tr>
<td>Hedge</td>
<td>0.3</td>
</tr>
<tr>
<td>Arable</td>
<td>0.1</td>
</tr>
</tbody>
</table>

**Legend:**
- **Green Bar:** Crop
- **Orange Bar:** Margin
- **Red Bar:** Adjacent habitat

Understanding impact of habitat connectivity on ticks across landscapes
Example of peri-urban tick & *Borrelia* area
Tick activity for seasonal forecasting

Early warning of increased tick activity
What ecological factors are driving high *Borrelia* prevalence rates in ticks?

- Deer numbers
- Habitat
- Game bird releases
- Seasonality
- Urban v rural

- Host seasonal dynamics
- Seasonal changes in tick infestation rates
- Seasonal changes in tick infection rates
- Differences in *Borrelia* genospecies cycles

Trans-ovarial transmission very low: <2%
**Role of small mammals at *I. ricinus* hosts**

- **Wood mouse (*Apodemus sylvaticus*)** most important rodent host of larvae in UK (Dorset)
  - Peak infestation in August
  - Support 120/larvae/hectare/day
  - Higher than Bank vole (Dorset: 30/larvae/ha/day)
  - Similar reports across Europe
- **Bank vole (*Myodes glareolus*)** develops resistance to tick bites
  - Reduced rates of engorgement
  - Reduced moulting rates
  - Wood mice support higher tick fecundity
- **Yellow-necked mouse (*Ap. flavicollis*)** – No UK studies, but similar data in Europe to WM
- **Black striped mouse (*Ap. agrarius*)** most important rodent host in continental Europe: UK absent
  - Larval infestation rates 2-3 x other small mammals
  - Nymphal infestation rates 5x
  - Infection rates 58% higher
  - In Germany contributes 5 times more spirochetal infection
  - Absence in UK is therefore important
Small mammals and *Borrelia afzelii*

- Small mammals are important amplifying hosts of *B. burgdorferi*, particularly *B. afzelii*
- Infected by infective nymphs or transovarially infected larvae
- Life long infection (7-40 months)
- Bank voles develop lower immunity to spirochaetes -> develop higher infection rates: possibly more important in transmission cycles, however engorged ticks develop less well
- Strong association between small mammal rodents with *B. afzelii*
- Studies in Slovakia on infection rates
  - Engorged nymphs from small mammals: 47% infected
  - Questing nymphs: 7% infected
Role of other small/medium sized mammals

- Shrews (*Sorex araneus, S. minutus*)
  - Efficient tick predators
  - European studies: 80% infestation rates; mean 40-60 larvae/shrew; 18% infect
- Dormice
  - Hazel dormouse (*Muscardinus avellanarius*) – arboreal, winter hibernation
  - Fat dormouse (*Glis glis*) – Germany: L infest 2-3x, N infest 20x
    - 9 yrs, synanthropic, 70% infected, 95% derived N
- Grey squirrel (*Sciurus carolinensis*)
  - Norfolk studies: mean L 8-19 compared to mouse L 1-4: upto 100 larvae
  - More important in spring/early summer – more arboreal in autumn
- Red squirrel (*Sciurus vulgaris*)
  - Switzerland study: 370L (64%), 380N (69%), 1 F on 1 animal cf. QL 3%, Qn 34%
  - 70% infection rates (Bbss, Ba)
- Siberian chipmunk (in France)
  - potential new host and reservoir
Role of other animals

- **Hedgehog** (*Erinaceus europaeus*)
  - Highly infested with ticks: Ireland study - >400L, 60N on 1 adult
  - Also infested with *I. hexagonus*:
    - In Switzerland – means 50L, 11N, 2.5 F *I. ricinus*
    - Co-infested in woodlands, mono-infested (IH) in urban areas: IH 24%
    - Silent cycle of transmission

- **Lizards**
  - Important dilution hosts in North America
  - Intensity of LD transmission negatively associated with Sand lizard dist in Ger.

- **Migratory birds** *(Swedish study)*
  - 23000 migrant birds surveyed, 2% infest, mean 2 ticks/bird, 98% IR
  - 30% of ticks in spring infected
  - >6.8m ticks enter Sweden each spring, 4.7m leave in autumn; 1.3m infected
  - Redwing – migratory restlessness reactivating latent infections
Role of woodland birds

- Ground feeding passerines are very important in Bb transmission
- Most important species (83% infested) are (Czech studies):
  - Robin (*Erithacus rubecula*)
  - Blackbird (*Turdus merula*)
  - Song thrush (*Turdus philomelos*)
- Robin fed 51% of all larvae feeding on birds
- Blackbird fed 54% of all nymphs (highest infestations 50 L and 20N/bird)
- Infection rates: 6-16% in larvae; 12-22% in nymphs
- *Turdus* sp. and *E. rubecula* very important amplifiers for *B. garinii and B. valaisiana*
Role of pheasant

- ~20 million pheasant (*Phasianus colchicus*) released in UK each year
- Densities in Dorset/Wiltshire studies: 500-1200 birds/km$^2$
- Feed large numbers of nymphs:
  - 43n/bird in April; 23n/bird in June
  - Most important host nymphal host
- Male birds 4x infestation rates – testosterone and immunosuppression
- Infection rates in ticks from pheasant (Dorset):
  - 22% infected, cf. 0% questing population
  - Mostly *B. garinii* (neuroborreliosis) and *B. valaisiana* – important amplifiers – no evidence of *B. afzelii* : possibly eliminated
- Feed large numbers of questing nymphs -> exposure; infected adult ticks
- Reduction in *B. afzelii* – zooprophylactic role
Role of deer

- Very important host for all stages

- Irish studies on Fallow deer:

<table>
<thead>
<tr>
<th></th>
<th>L/50m</th>
<th>N/30s</th>
<th>A/30s</th>
<th>Inf qN</th>
<th>Inf qA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deer</td>
<td>22-118</td>
<td>33-34</td>
<td>5-6.6</td>
<td>1.7%</td>
<td>3.1%</td>
</tr>
<tr>
<td>No deer</td>
<td>1.5-5.5</td>
<td>1.6-12.5</td>
<td>0.1-1.2</td>
<td>12.4%</td>
<td>17.9%</td>
</tr>
</tbody>
</table>

- Dilution hosts for *Bb*
  - Swedish studies
    - Compared moulted ticks from deer (0%) to questing N (7-11%)
    - 20% n infection rates: need 300,000 nymphs for infection
    - Typical infestation <100 nymphs
    - 100 ticks/kg vole v 3.7 ticks/kg deer -> immunity, low infection rates
  - Role of deer: increase tick numbers; dilute infection rates -> sustain tick pop
Role of livestock

- **Sheep**
  - Upland sheep – feed 80% of all larvae, >95% all N and A
  - No systemic infection in sheep
  - Studies in Scotland confirm co-feeding transmission
    - N:A 9cms; transmission during max. peaks of infestation

- **Cattle**
  - Zooprophylactic role on transmission
  - French studies: infection rates in questing ticks inside/outside cattle enclosures
    - 4x lower infection rates in Nymphs inside enclosures
    - 6x lower in Adults
  - Could we use cattle to dilute infection rates, and mop up ticks?
Could understanding the ecology of *Borrelia burgdorferi* be employed in understanding:

1. Rates of exposure
2. Determinants for high risk areas
3. Targeted management/grazing regimes to minimise ticks and *Borrelia*

- Host seasonal dynamics
- Seasonal changes in tick infestation rates
- Seasonal changes in tick infection rates
- Differences in Borrelia genospecies cycles

Trans-ovarial transmission very low: <2%
Mapping *Borrelia* infection rates in ticks across a landscape – South Wiltshire

- Heterogeneity of infection rates
- Impact of habitats and hosts
- Differences in genospecies rates

Understanding ecological drivers of *Borrelia burgdorferi* Wiltshire tick abundance

**Wiltshire tick abundance**

**Heterogeneity of *B. burgdorferi* prevalence in questing ticks – pilot study**

- Seven regions of southern England compared (Exmoor, Dartmoor, New Forest, Surrey, Wiltshire, London, Salisbury)
- Prevalence ranged from 0-10%
- Urban fringe sites as high as 9%
- High biodiverse woodland sites had low prevalence
- 4 out of 5 of the sites showed dominance of one genospecies

Tick abundance per 5m²

Habitat type

- Woodland High
- Woodland Low
- Woodland edge
- Chalk scrub
- Chalk grassland

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