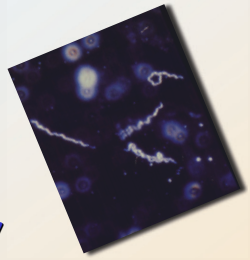

How does tick ecology determine risk?

Sarah Randolph

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LDA, Leicester, July.2008

Tick species found in the UK

Small rodents	*Ixodes acuminatus*
Water voles	*Ixodes apronophorus*
Birds (hole nesting)	*Ixodes arboricola*
Birds (cliffs & buildings)	*Ixodes caledonicus*
Foxes, badgers (in lairs)	*Ixodes canisuga*
Birds (small passerines)	*Ixodes frontalis*
Hedgehogs (in nests)	*Ixodes hexagonus*
Birds (sand martins)	*Ixodes lividus*
All vertebrates in reach	*Ixodes ricinus*
Birds (marine, coastal)	*Ixodes rothschildi*
Birds (marine, coastal)	*Ixodes unicavatus*
Rabbits	*Ixodes ventalloi*
Bats	*Ixodes vespertilionis*
Sea birds	*Ixodes uriae*
Small rodents (in burrows)	*Ixodes trianguliceps*
Livestock	*Dermacentor reticulatus*
Tortoises	*Hyalomma aegyptium*
Birds (small migrants)	*Hyalomma m. marginatum*
Sheep, cattle, birds	*Haemaphysalis punctata*
Dogs (kennels & houses)	*Rhipicephalus sanguineus*
Pigeons	*Argas reflexus*
Bats	*Argas vespertilionis*
Sea birds	*Ornithodoros maritimus*

Adult *Ixodes ricinus*

Examples of tick-borne parasites from UK and Europe

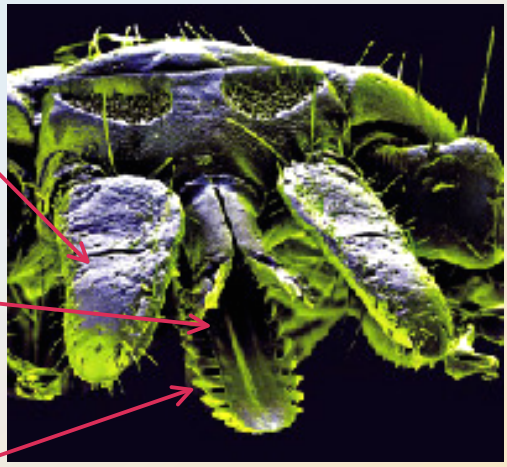
	DISEASE - medical/veterinary	
■ VIRUSES	Tick-borne Encephalitis	Europe
	Louping ill	UK
■ BACTERIA	*Borrelia burgdorferi* s.l. (Lyme borreliosis)	N hemisphere
	Francisella tularensis (Tularemia)	N hemisphere
■ RICKETTSIA	*Anaplasma phagocytophilum* (Tick-borne fever) (Human Ehrlichiosis)	UK, Europe
	Rickettsia conori (Med spotted fever)	S Europe
	Coxiella bourneti (Q fever)	Europe
■ PIROPLASMS	*Babesia* divergens (redwater)	UK, Europe
	Babesia microti	UK, Europe

Adult *Ixodes ricinus*

Ticks as blood feeders

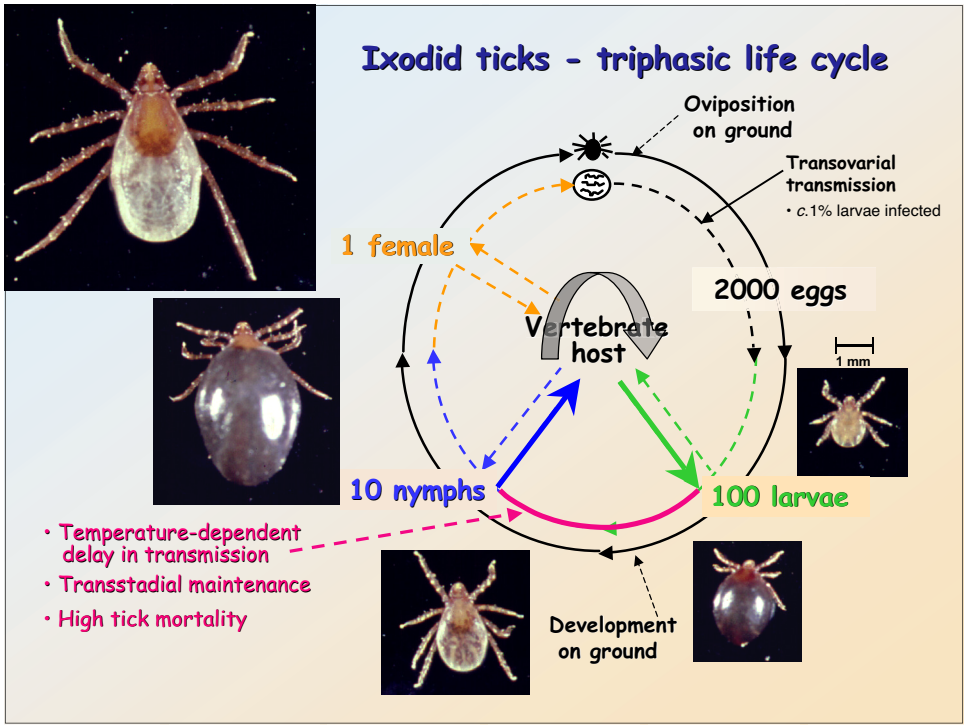
Tick mouthparts (chelicerae and hypostome), ventral view

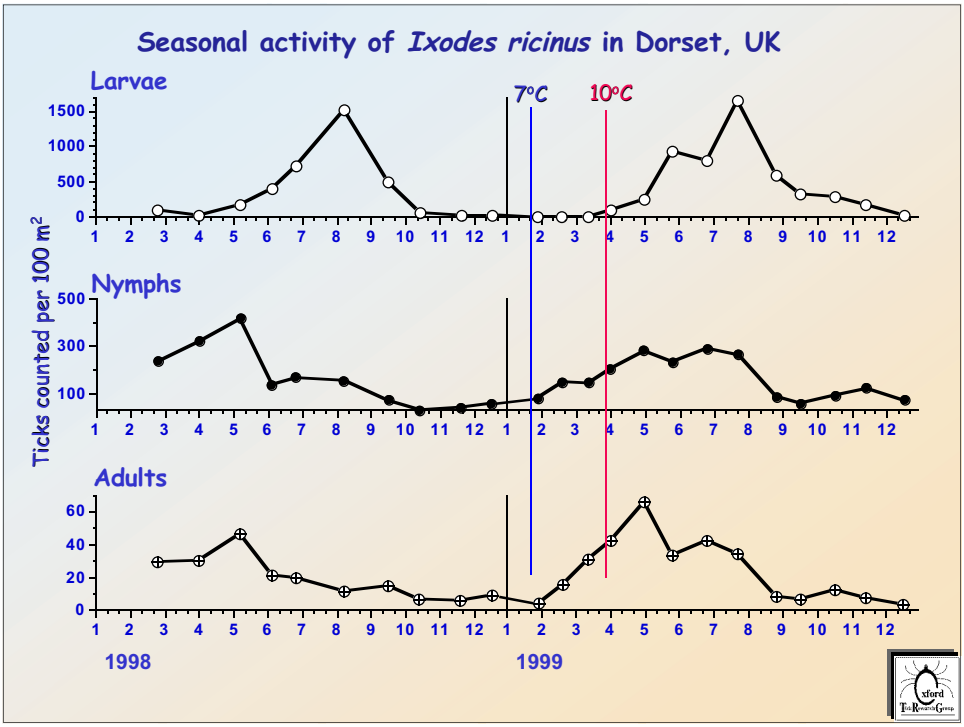
Tick mouthparts, front dorsal view



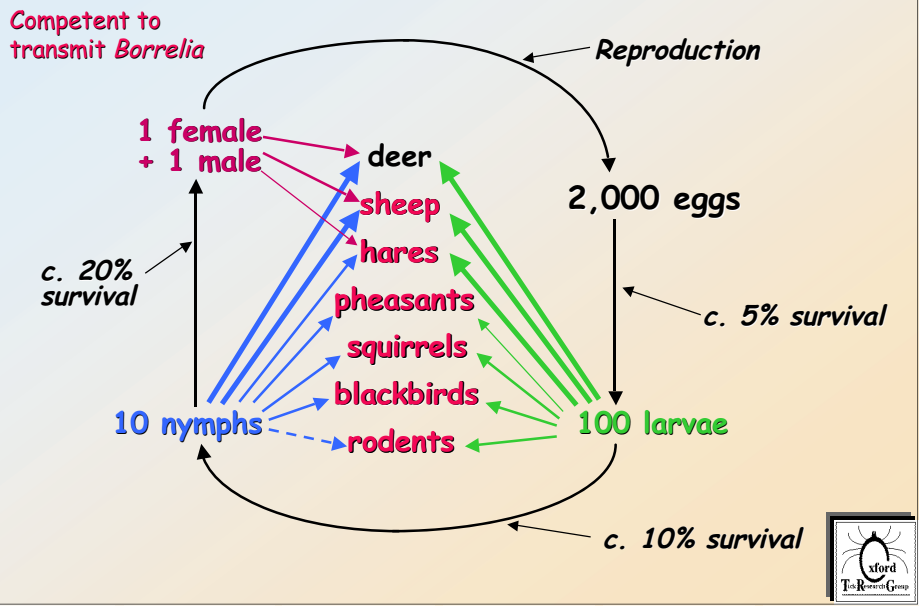
Ticks as vectors
No wings

- Very immobile
- Only feed once per life stage - larva, nymph, adult


Ixodid ticks - triphasic life cycle
Oviposition on ground
Transovarial transmission
• c.1% larvae infected
1 female
2000 eggs
Vertebrate host
1 mm
10 nymphs
100 larvae
• Temperature-dependent delay in transmission
• Transstadial maintenance
• High tick mortality
Development on ground


Seasonal activity of Ixodes ricinus in Dorset, UK
Larvae
7°C
10°C
Nymphs
Adults
Ticks counted per 100 m²
1998
1999

Ixodes ricinus life cycle with typical reproductive rates, mortality rates and host relationships



Biotic variability in Lyme disease systems

- Genetic diversity of the *Borrelia burgdorferi* complex
  - *B. burgdorferi s.s.* - arthritis - mammals
  - *B. afzelii* - cutaneous disorders - mammals
  - *B. garinii* - neurological symptoms - birds
  - *B. valaisiana* - birds
  - *B. lusitaniae* - lizards?
- Host diversity
  - Feed different fractions of tick populations
  - Differential transmission competence for each *Borrelia* genospecies

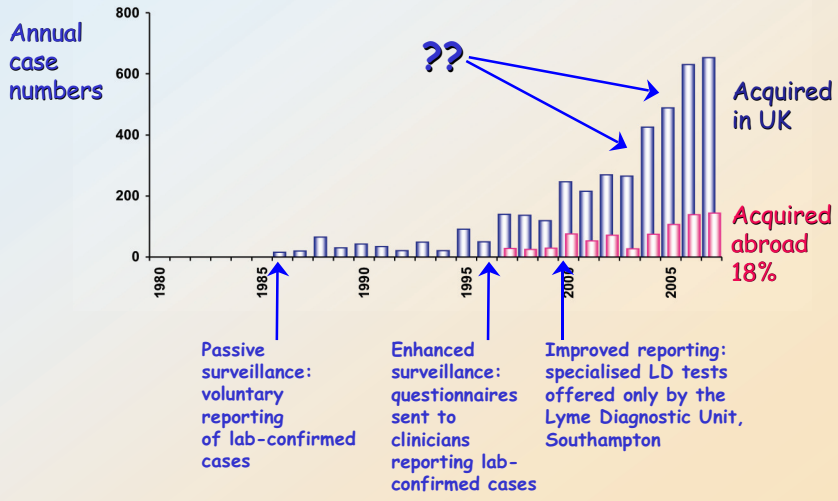
Deer feed adult ticks, but cannot transmit *Borrelia*

Epidemiology

What determines variation in risk
in space and time?

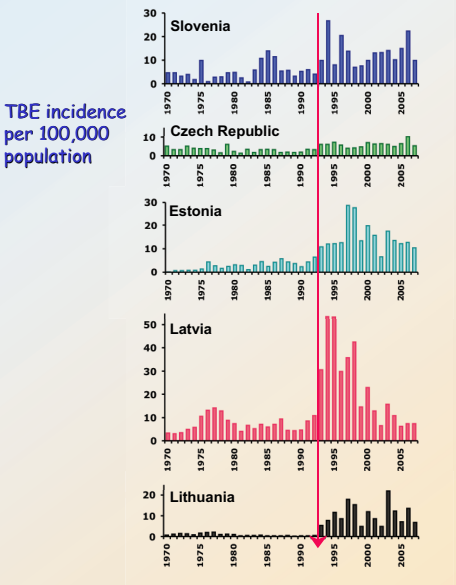
Increasing laboratory-confirmed cases of Lyme disease in England and Wales

Estimated 1,000-2,000 additional cases
diagnosed on clinical symptoms without lab-confirmation



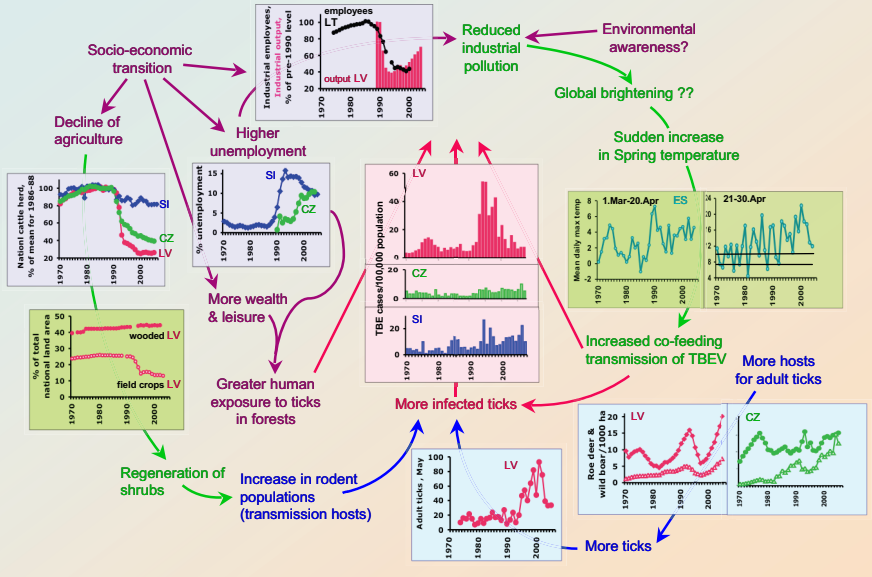
What sort of change in which conditions?

Differential increase in national mean TBE incidence from 1993



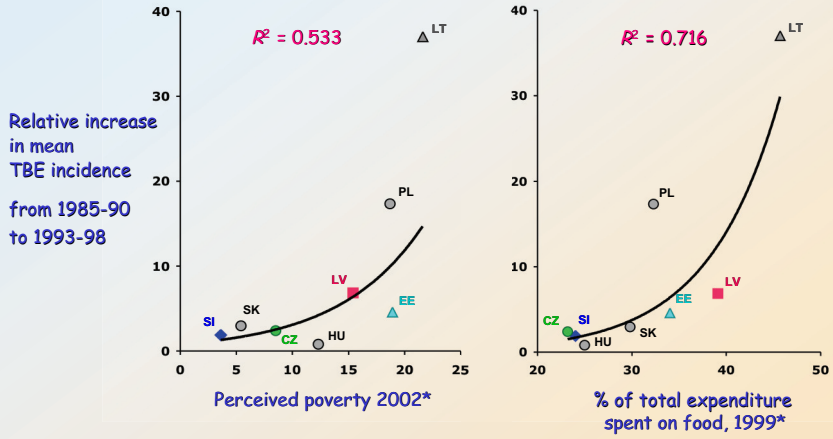
Network of independent but synergistic biological and non-biological factors

Examples of data from Estonia, Latvia, Lithuania, Slovenia and Czech Republic.



updated from *PLoS ONE* 2007 e500

Correlations between socio-economic factors and increases in TBE incidence across CEE countries



- Shift from correlations in time to correlations in space - substantiates causality

Šumilo et al (2008) *Revs Med Virol* **18**, 81-95

*Data from Heyns 2005, *Ann Rev Sociol* 31, 163-97

What are risk factors and who is at greatest risk?

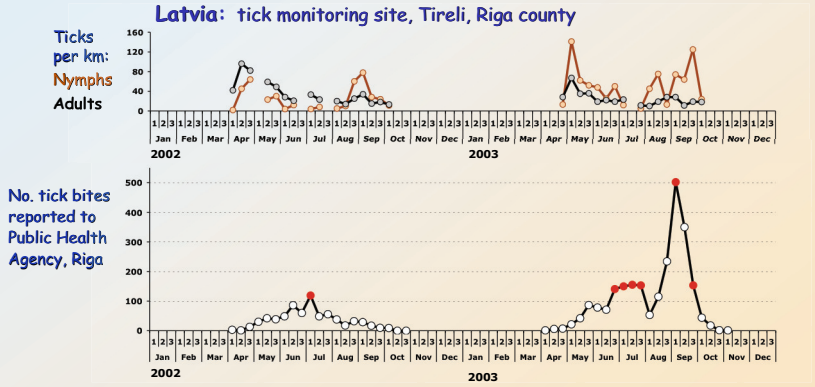
- Survey data from Latvia, 2001:
  - Unemployment and low income - significant factors pre-disposing people to
    - visit forests frequently
    - not to be protected by TBE vaccination
  - Increased risk of infection with TBE virus

Šumilo, D *et al* (2008) *Vaccine* 26, 2580-8

Data source: SKDS population survey, 2001

Human-tick contact rates influenced by human behaviour and weather

- Mushroom or berry collecting is most common purpose of frequent forest visits
  - Principal reason for women, older, less educated, unemployed, pensioners, low earners
  - Risk of tick bite highest for mushroom collectors (x 2.8) and forest workers (x 4)



  - Mushrooms grow best when it rains
  - Dry weekends following week with heavy rainfall (●):
    tick bites more common when weather favours mushroom harvest, independent of tick abundance

Šumilo, D *et al* (2008) *Vaccine* 26, 2580-8

Data source: Public Health Agency of Latvia

Other tick-borne infections of humans in UK transmitted by *I. ricinus*

- **Louping ill**
  - caused by virus of tick-borne encephalitis group
  - common infection of sheep and grouse
  - 34 human cases recorded between 1934 and 1991
- **Human Granulocytic Ehrlichiosis**
  - caused by rickettsia *Anaplasma phagocytophylum*
  - same microbe that causes sheep-borne fever
  - 2-7% *I. ricinus* ticks infected; >50% roe deer sero-+ve
- **Babesiosis**
  - *Babesia divergens* causes red-water in cattle
  - *Babesia microti* circulates amongst rodents
  - sporadic human cases recorded - splenectomy is risk factor
  - increasing incidence in USA