Ecology of Ticks and Tick-borne Diseases

Erik Matthysen

Evolutionary Ecology Group

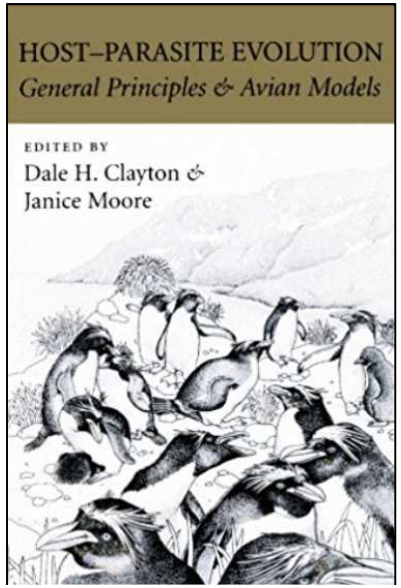
(hard) ticks: basic facts

Ticks feed once per stage (several days)

Long generation time (one to several years)

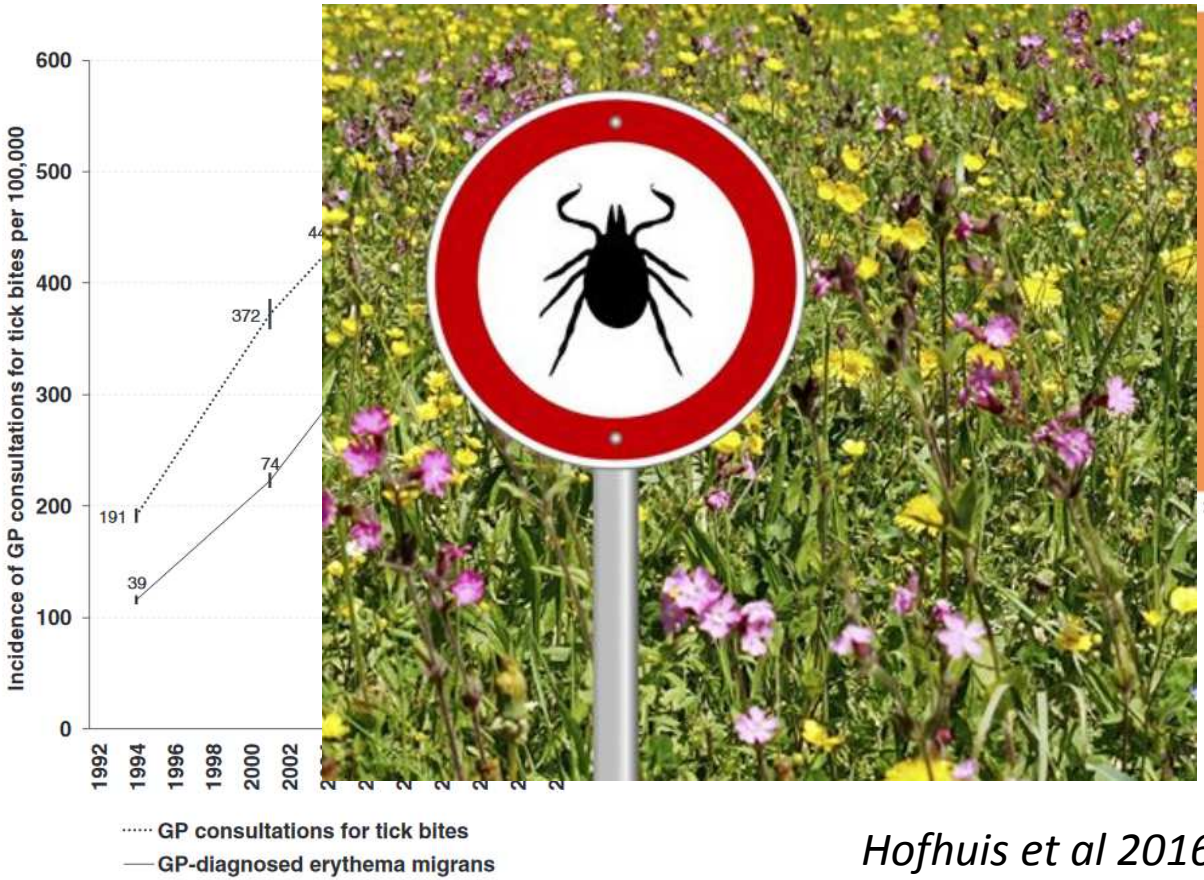
Most are specialized on one or few host species

14 species (+ potentially 10) in Belgium
(Obsomer et al 2013)

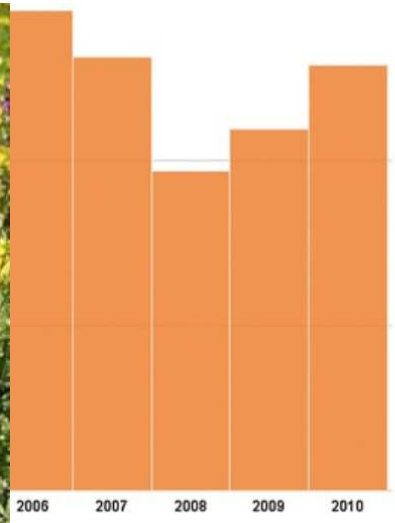


Tick bites cause Lyme borreliosis

GP consultations and Erythema migrans diagnoses, NL, 1994-2014



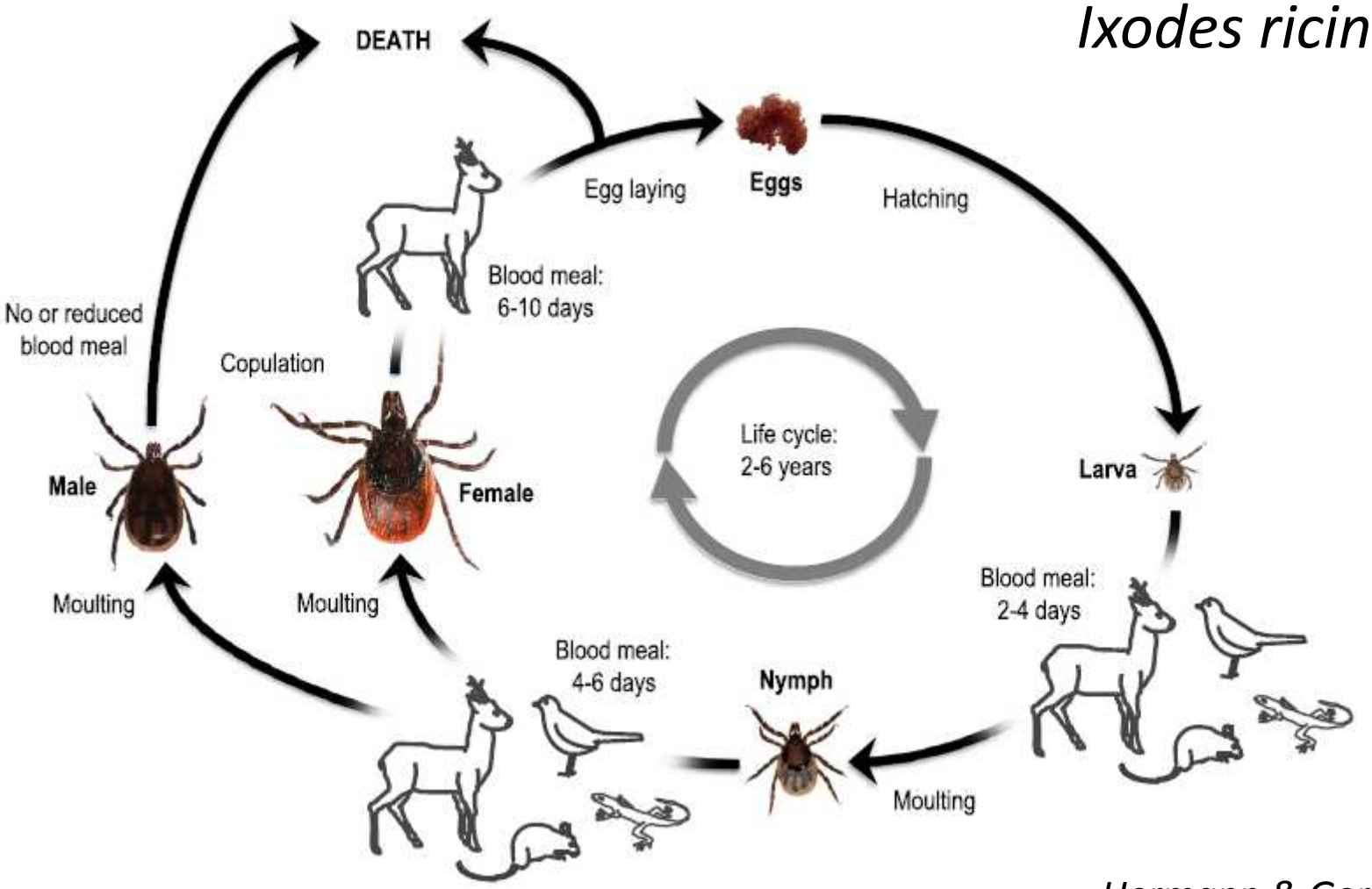
Hospitalizations for LB per year, Belgium, 2002-2010



Hofhuis et al 2016; Bleyenheuft et al 2015

The tick life cycle

Ixodes ricinus



Hermann & Gern 2015

Seasonal activity

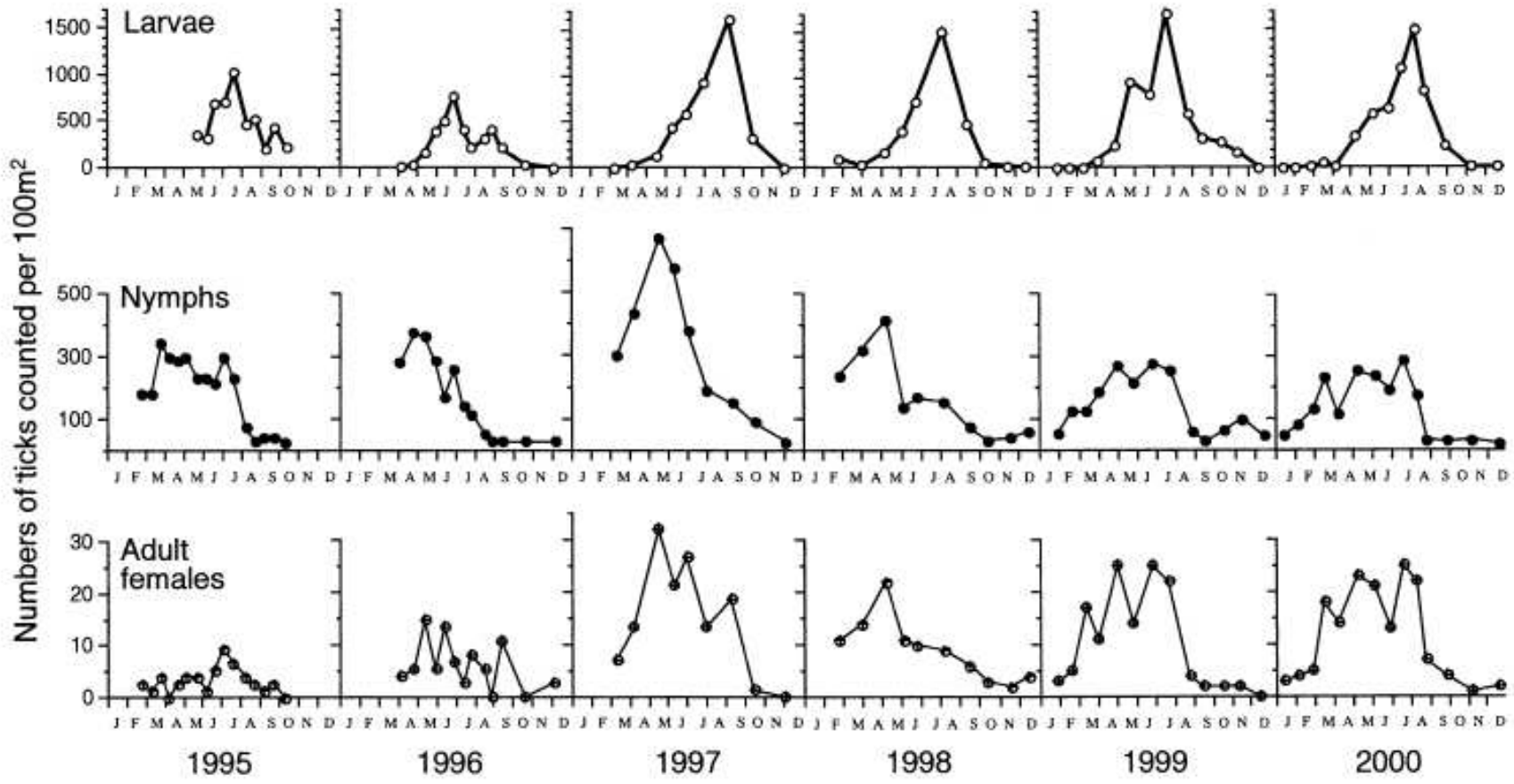
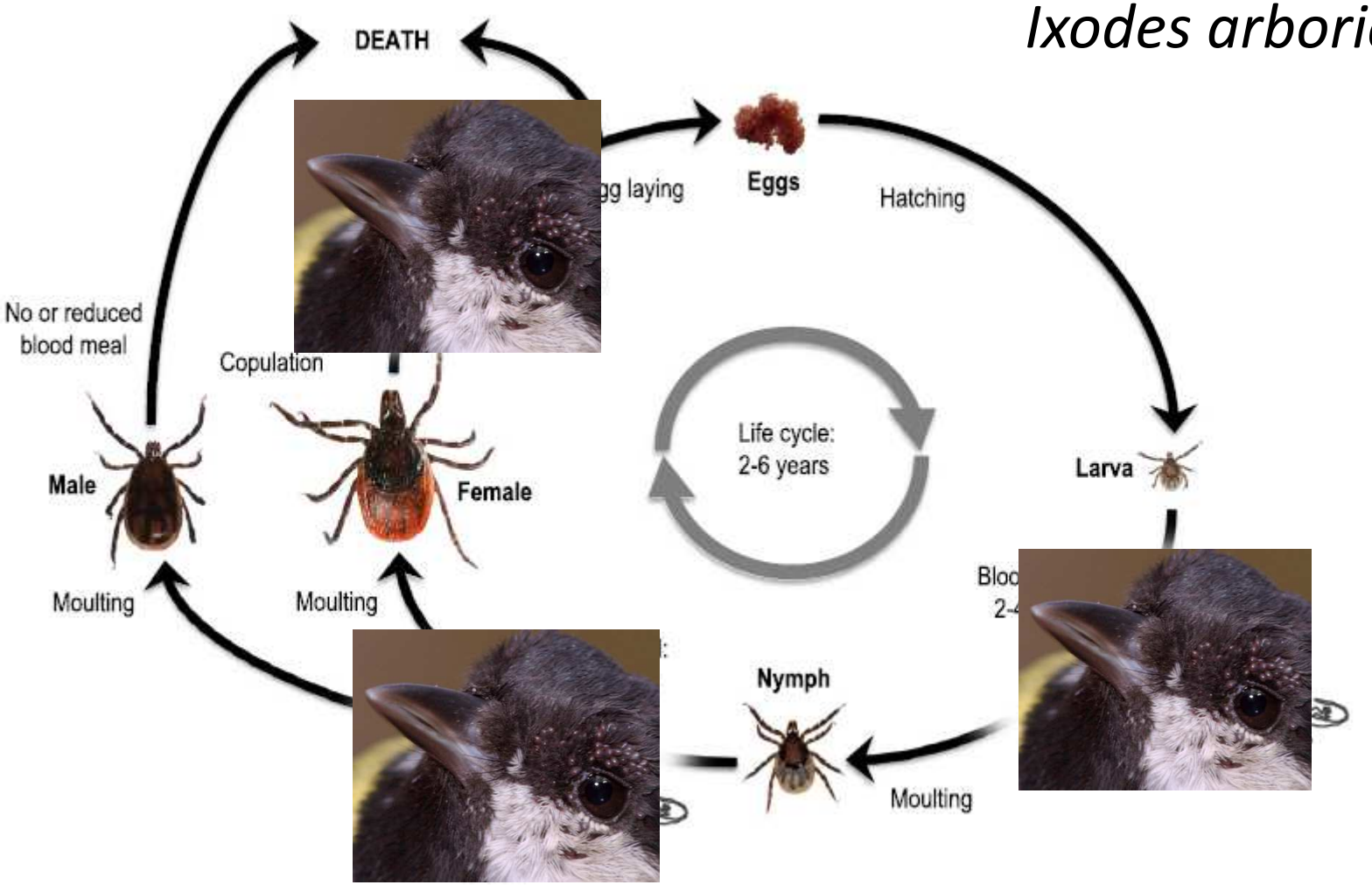


Fig. 3. Annual variation in the seasonal patterns of abundance of questing *Ixodes ricinus* counted at Wimborne St. Giles, Dorset.

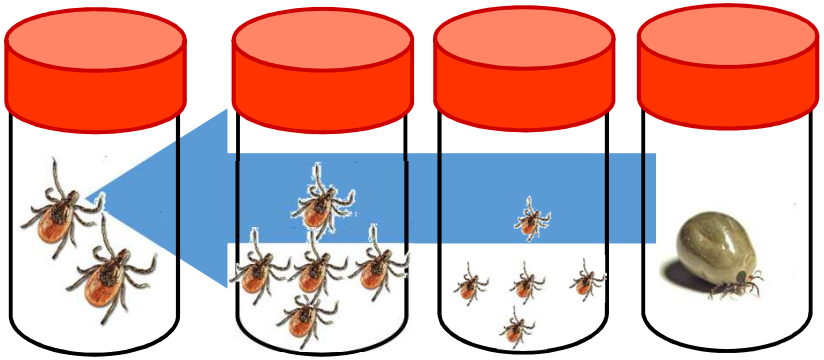
Randolph et al. 2002

Specialized tick life cycle

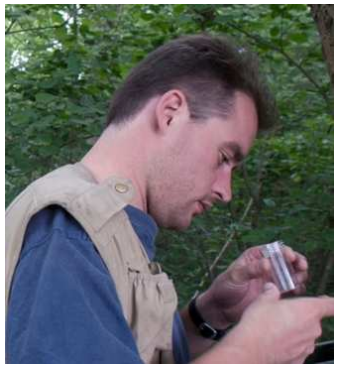
Ixodes arboricola



Ticks as experimental model system



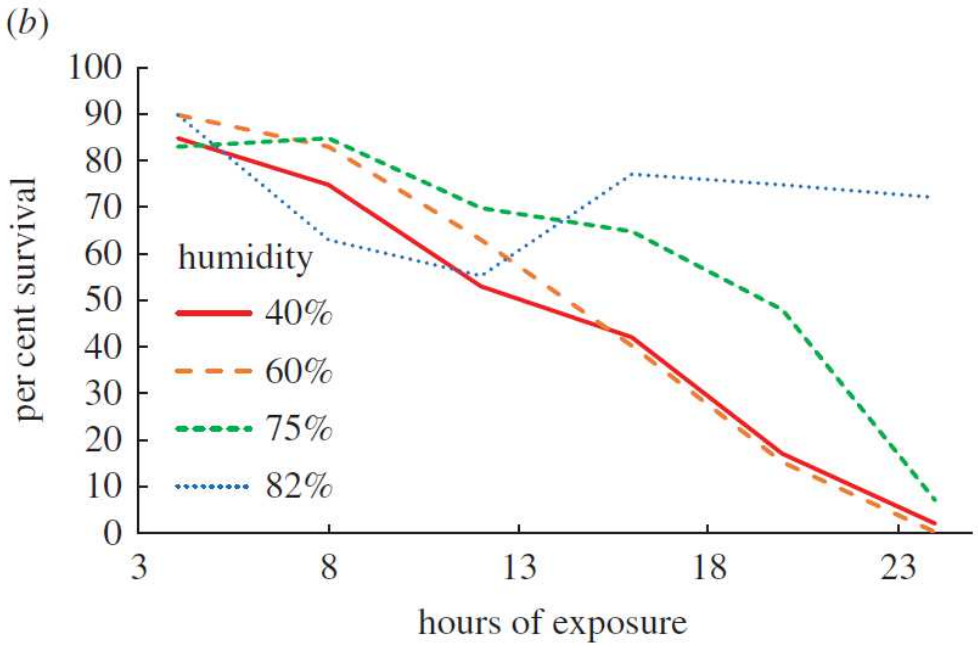
t°
H_2O



Dieter Heylen

It’s hard to be a tick…

- Survive **up to a year** between blood meals
- High sensitivity to **desiccation**



Kilpatrick et al. 2017

It’s hard to be a tick…

- Survive up to a year between blood meals
- High sensitivity to desiccation
- Need to find the **right host** species

- Resist host **immune system** for multiple days
- **Ca. one larva per thousand** becomes adult

Drivers of tick abundance

- Good conditions for tick **survival** (soil humidity)
- Suitable vegetation for "**questing**"
- **Suitable hosts** for feeding

Host resistance to ticks

Figure 2. Rodent species of The Netherlands that are commonly selected as blood host by *Ixodes ricinus* lar
and as reservoir host for *Borrelia afzelii*. (A) Wood mouse (*Apodemus sylvaticus*) and (B) bank vole (*Myo*
glareolus). Photos by Hans Hillewaert (*A. sylvaticus*, CC BY-SA 3.0) and Evan J

Van Duivendijk 2016

“Tick killers”

In one season, a single possum can kill up to 5000 ticks (*Ixodes scapularis)*

Keesing et al. 2009

Changes in tick distribution

- Higher elevations (e.g. Czech Republic)
- Higher latitudes (e.g. Sweden)

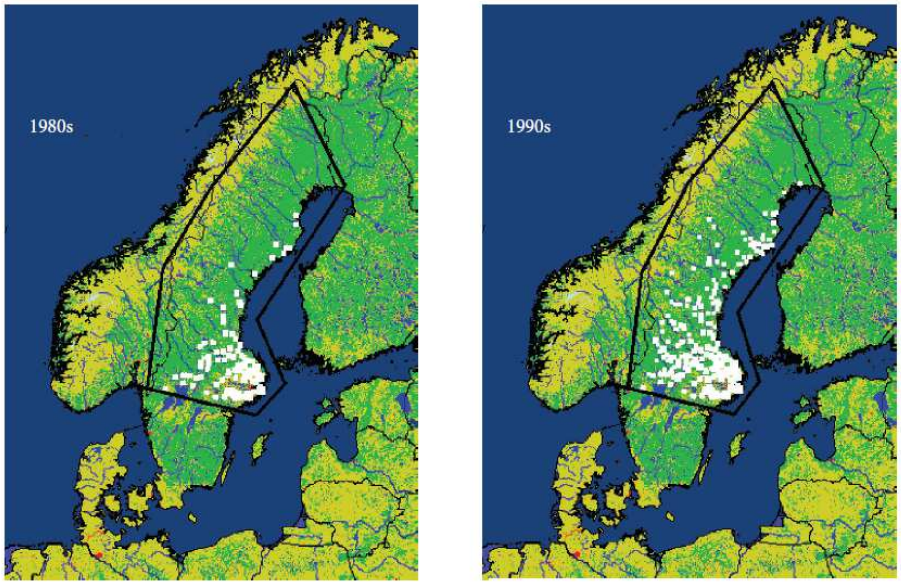


FIGURE 1: Changes in tick distribution in northern and central Sweden. White dots illustrate districts in Sweden where ticks were reporte be present before 1980 (a) and in 1994-1995 (b). The study region is within the black line (Lindgren et al. 2000, [12] with permission fr *Environmental Health Perspectives*).

Gray et al. 2009

Changes in tick abundance

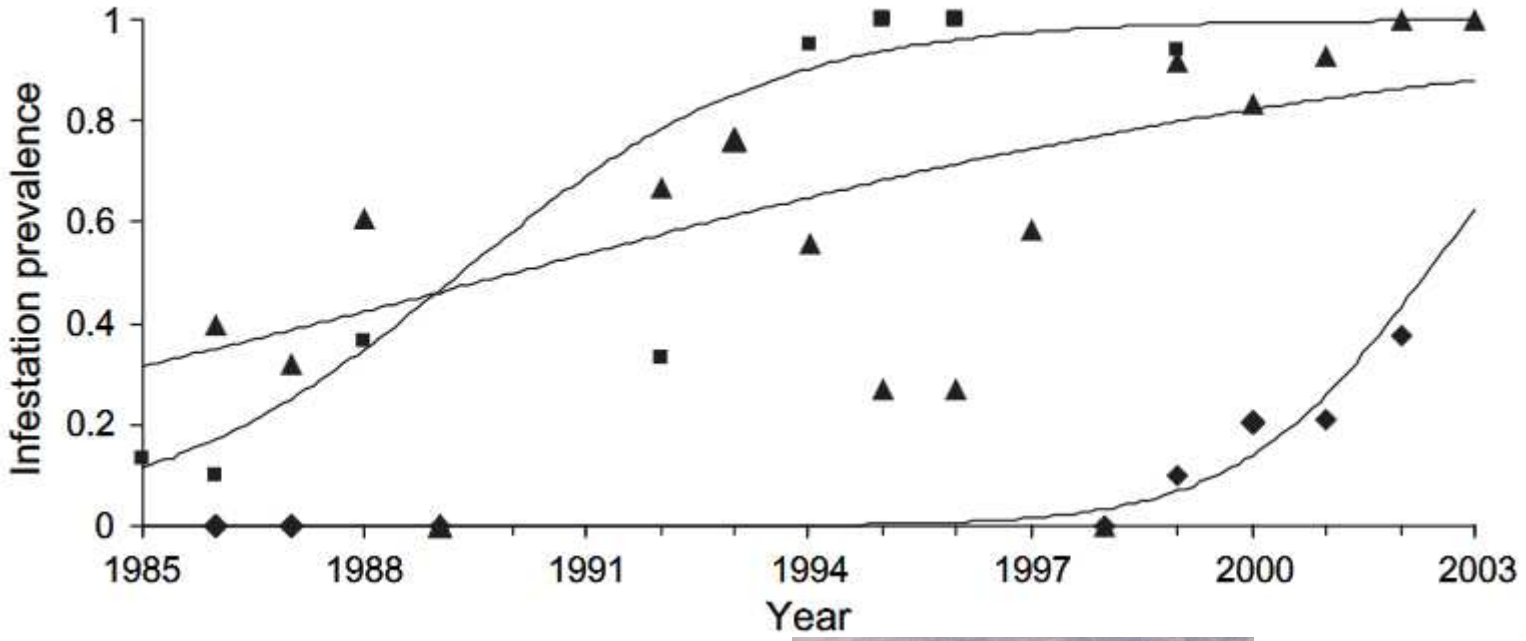


Fig. 4. Trends in tick infestation prevalence on red grouse on three Scottish estates: G1 (squares), G2 (diamonds), and G3 (triangles). Solid lines indicate a statistically significant generalized linear model with binomial error. Locations of estates are shown in Fig. 6.

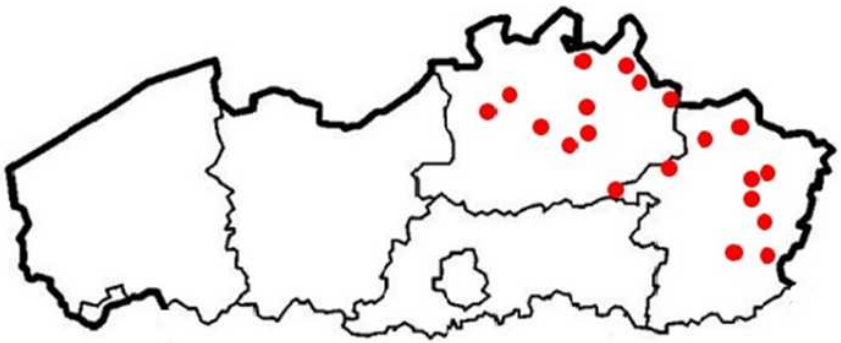
Randolph et al. 2008

Borrelia burgdorferi ss: basic facts

- **20 genospecies**, at least 10 in Belgium
- Association with specific **hosts**
- Association with specific **vectors**
- Different **clinical manifestations** (Lyme disease)

Borrelia in questing ticks

- Across Europe: ca 10%
- Prevalence varies less over time than tick density
- Forests in Kempen: ca 15%



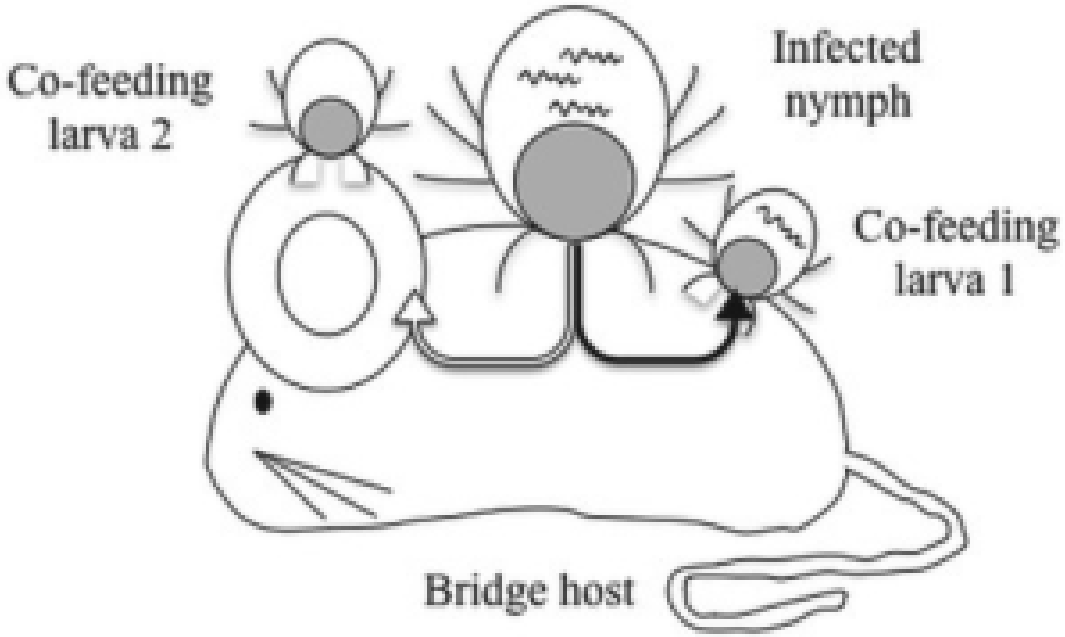
Ruyts et al. 2016

Transmission of Borrelia

~~**Transovarial**~~

Transstadial

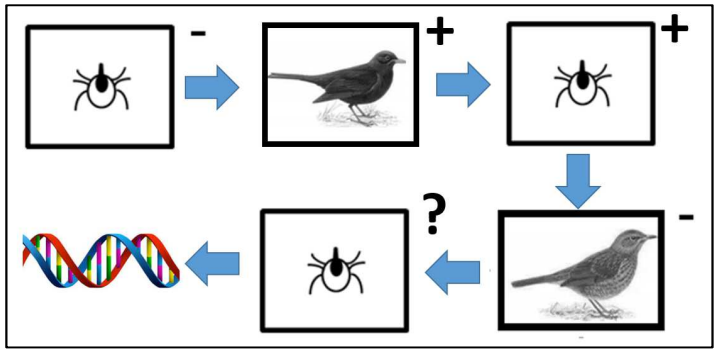
Co-feeding

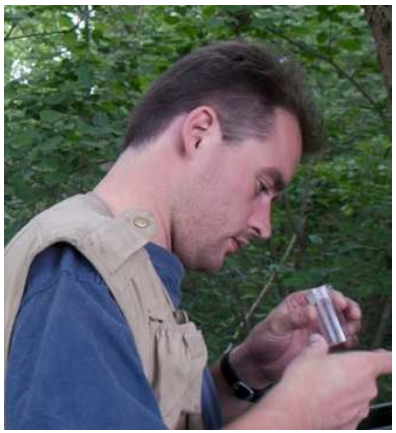


Voordouw 2014

Hosts and vectors differ in competence

Hosts and vectors differ in competence





	I. ricinus	*I. frontalis*	*I. arboricola*
B. garinii	V	C	C
B. valaisiana	V	C	C
B. turdi	V	V	I
B. burgdorferi s.s.	C*	C	?

Heylen et al. 2014, 2016, 2017

TOPICAL REVIEW

Few vertebrate species dominate the *Borrelia burgdorferi* s.l. life cycle

T R Hofmeester[1,4], E C Coipan[2,4], S E van Wieren[1], H H T Prins[1], W Takken[3] and H Sprong[2]

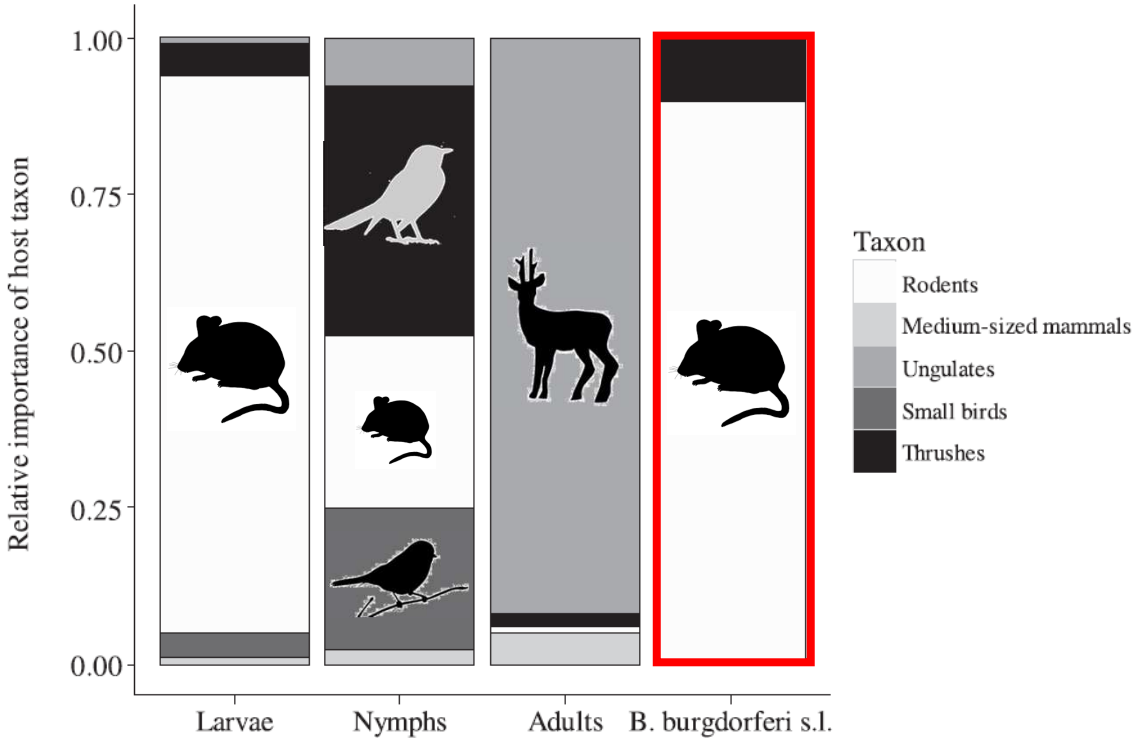


Figure 2. Quantification of the relative importance of different host groups feeding *I. ricinus* larvae, nymphs and adults, and infecting *I. ricinus* larvae with *B. burgdorferi*.

Main hosts for *Borrelia* infections

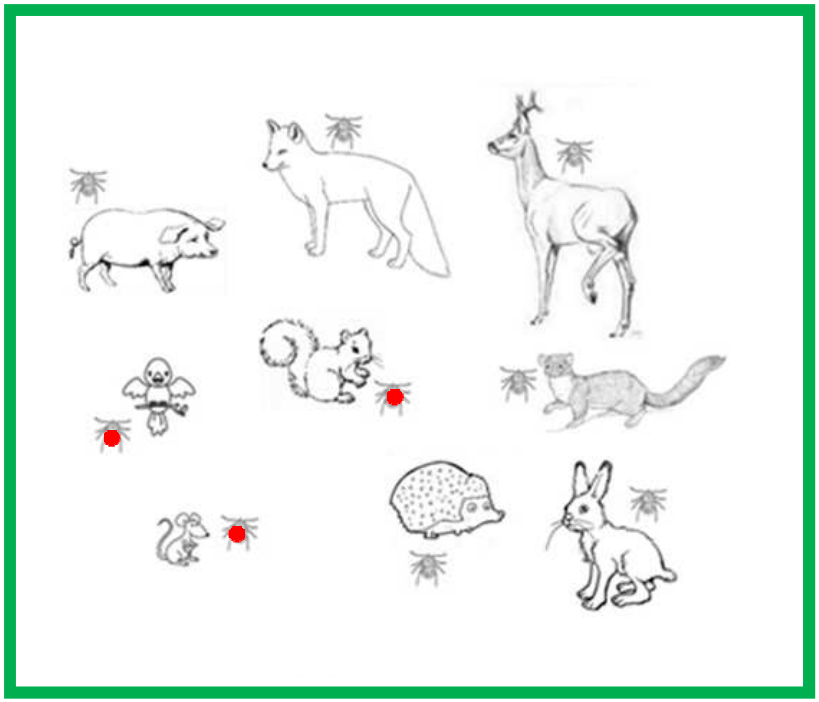


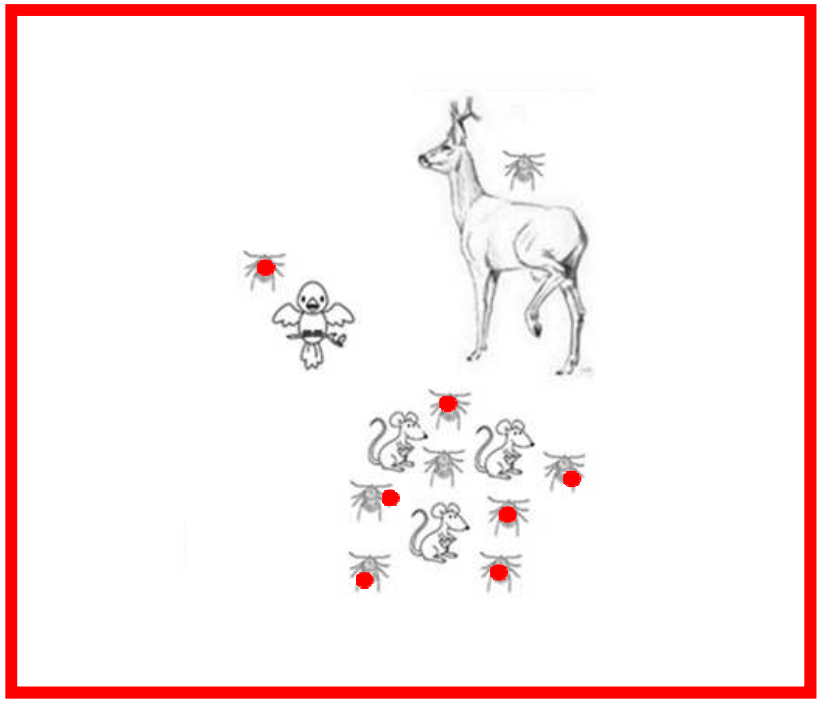



Germany **Sweden** **Netherlands**

Kilpatrick et al. 2017, Van Duijvendijk 2016

The dilution effect

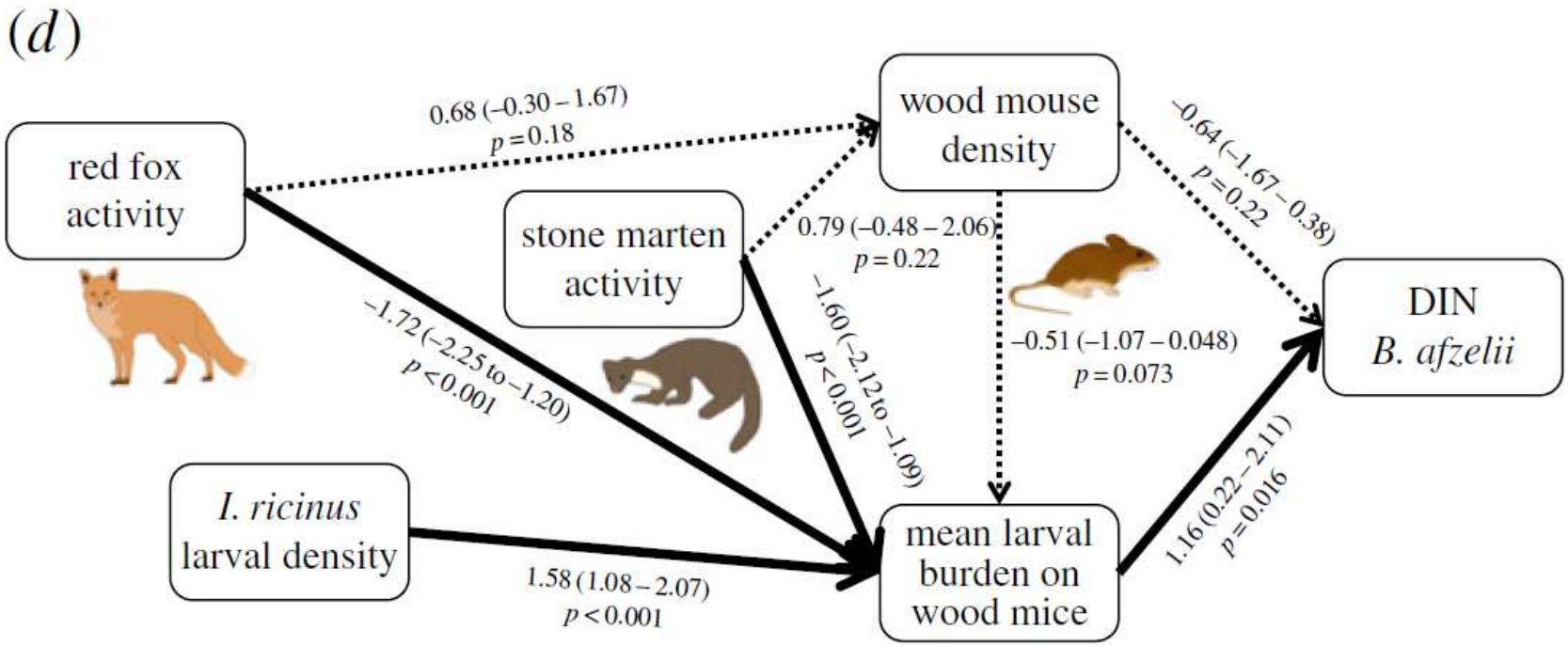




Hypothesis: higher host diversity >> less *Borrelia*

Not well supported in Europe

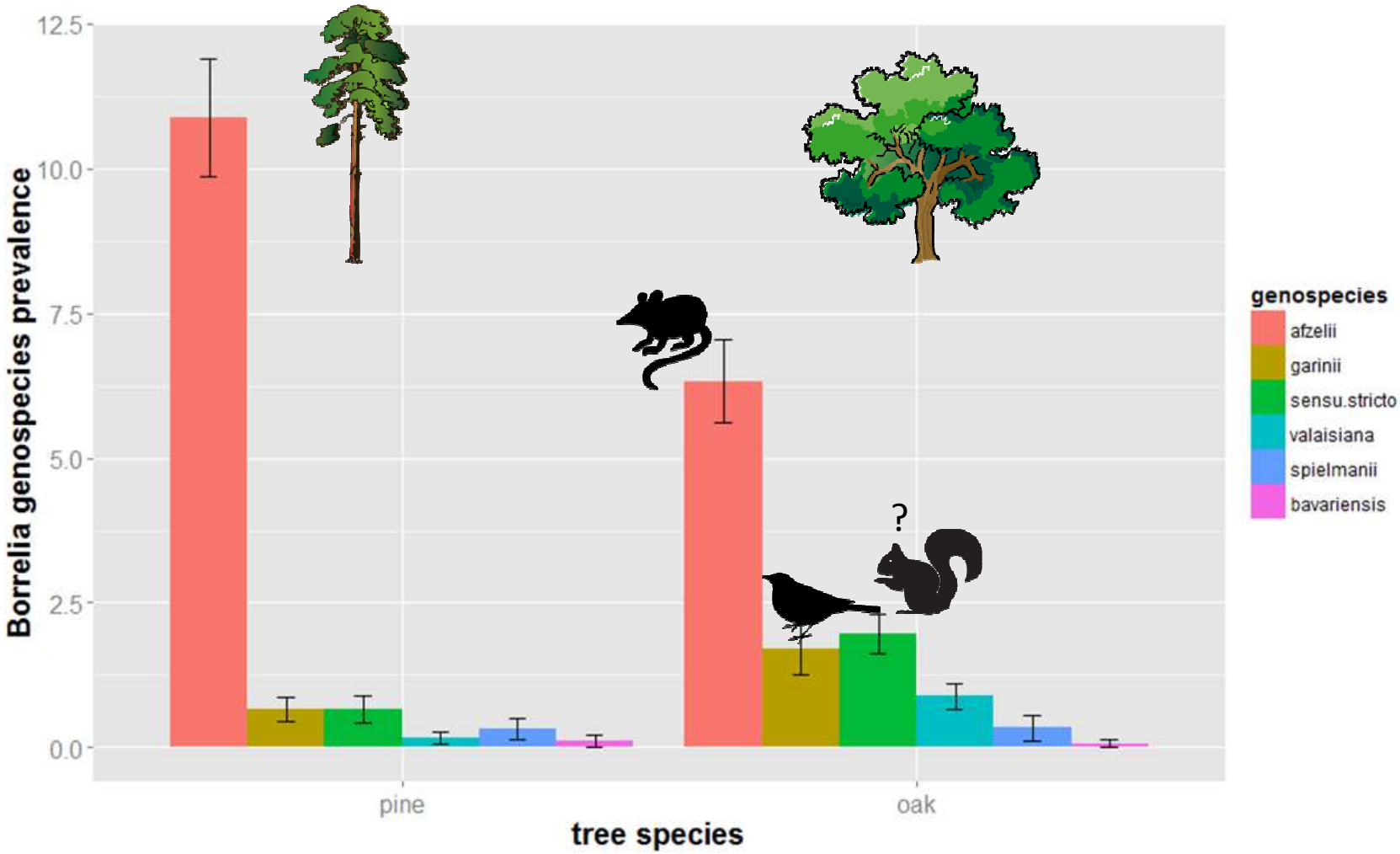
The predator effect



Hypothesis: predators reduce tick load by affecting prey behaviour

Hofmeester et al. 2017

Variation in *Borrelia* communities



Ruyts et al. 2016

Other tick-borne pathogens

transovarial

Borrelia miyamotoi
Babesia microti
C Neoehrlichia mikurensis
TBEV-Eu

Anaplasma phagocytophilum

Babesia divergens
Babesia venatorum

Rickettsia helvetica

Jahfari & Sprong 2016

Covariation in pathogens

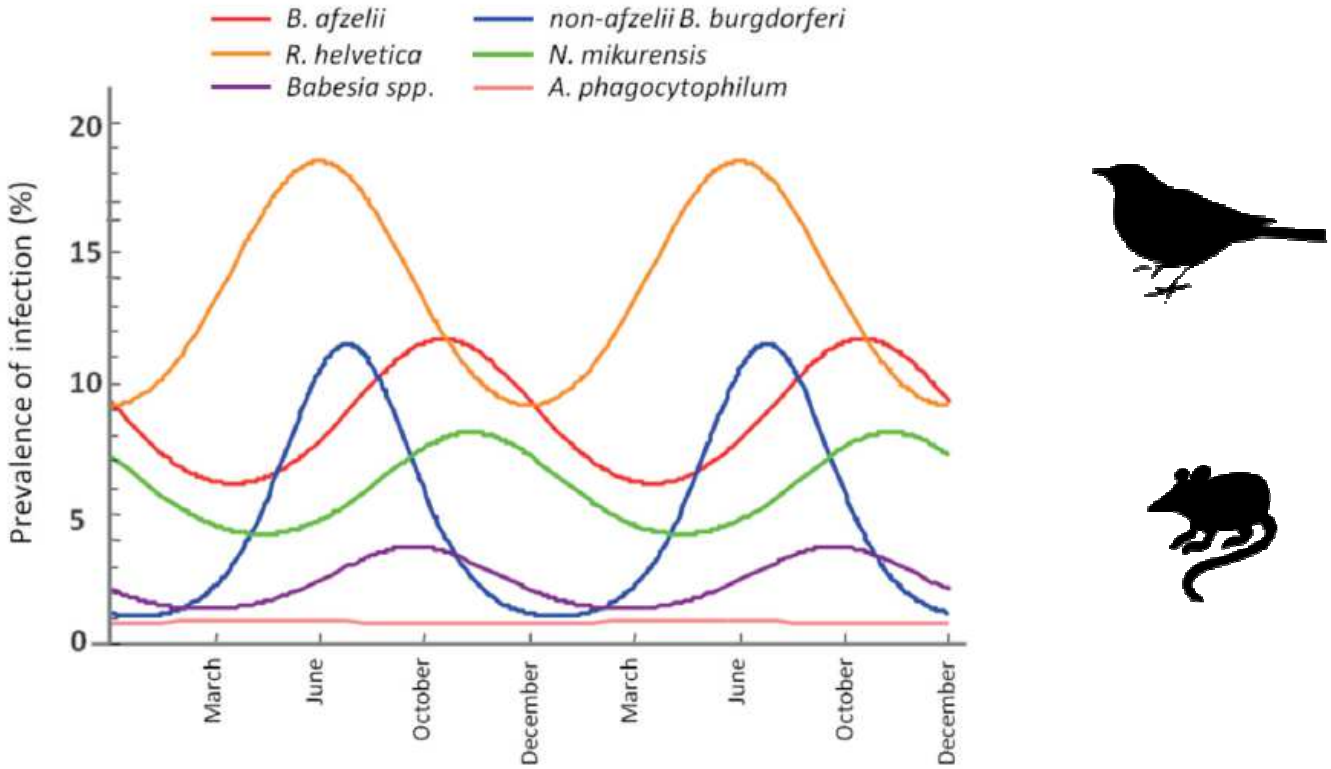


Figure 6: Seasonal variation of the infection rate in ticks. The maximum infection rates of non-*afzelii B. burgdorferi*, and *R. helvetica* are in June, while the amplitudes of *B. afzelii*, N. mikurensis, and *Babesia spp.* overlap in October.

Coipan et al. 2013

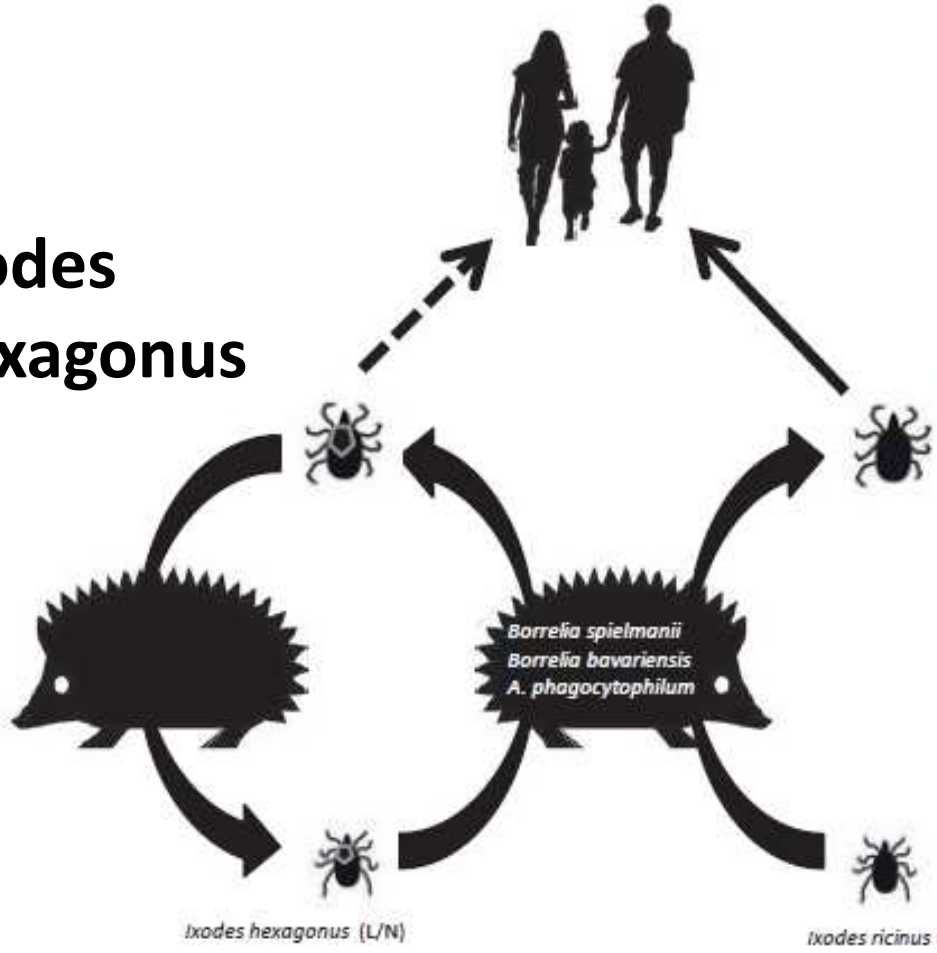
Cryptic cycles

Ixodes frontalis
Borrelia turdi

Heylen et al 2017

Ixodes hexagonus

Ixodes ricinus



Jahfari & Sprong 2016

Figure 1. The cryptic cycle of human pathogens via *Ixodes hexagonus* and its host, the hedgehog. When feeding on an infected hedgehog, the generalist tick *Ixodes ricinus* gets infected with pathogens and transmits them to another host species, for example humans. L/N is larva/ nymph and N/A is nymph/ adult.

Perspectives

Fine-scale distribution of ticks ~ forest management

Interaction between pathogens/microbiota

Influence of *Borrelia* on ticks and hosts

Urban connectivity

Forest management

mowing, fencing, channeling recreation…
“sheep mopping”

Herrmann and Gern *Parasites & Vectors* (2015) 8:6
DOI 10.1186/s13071-014-0526-2

Parasites & Vectors

REVIEW Open Access

Search for blood or water is influenced by *Borrelia burgdorferi* in *Ixodes ricinus*

Coralie Herrmann* and Lise Gern*

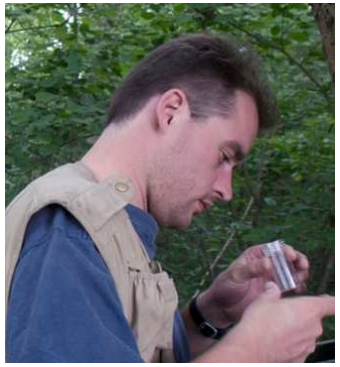
A Borrelia afzelii Infection Increases Larval Tick Burden on Myodes glareolus (Rodentia: Cricetidae) and Nymphal Body Weight of Ixodes ricinus (Acari: Ixodidae)

Gilian van Duijvendijk ✉, Wouter van Andel, Manoj Fonville, Gerrit Gort, Joppe W. Hovius, Hein Sprong, Willem Takken

Journal of Medical Entomology, Volume 54, Issue 2, 1 March 2017, Pages

TBD & urbanization

Thanks for your attention!



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