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EUROPEAN CENTRE FOR
DISEASE PREVENTION
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"European Network for Arthropod Vector Surveillance for Human Public Health"

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Driving forces for change in distribution of *Ixodes ricinus* in Europe

WP 2.2

Objectives 2010-11

- Risk assessment/factsheets on ticks

- Driving forces for change in distribution of
  - *Ixodes ricinus* – vector of LB, TBE etc.
  - *Hyalomma marginatum* – vector of CCHFV

  - For Hm, focus given on defining habitats
  - Not intended to deal with pathogen transmisison cycles.

Acknowledgements – *Ixodes ricinus*
105 papers/personal communications

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Driving forces

- Climatic effects at altitude
  - Evidence, explanations
  - Effects on hosts and vegetation
  - Effects on abundance, effect of latitude, aspect
  - Lower altitude restrictions
- Climatic effects at latitude
  - Growing season, impacts on host, vegetation
- Habitat patchiness/ connectivity
- Expansion of tick hosts (deer, boar)
- Urban green corridors
- Anthropogenic factors
- Overcoming lack of historical data to assess change
- Expansion to new territories
- No evidence of change

Altitudinal expansion - evidence

- Bosnia & Herzegovina
  - IR up to 1180m asl. Expansion from 800-900m in 1950s-60s (Omeragic 2010)
- Czech republic
  - Increase in altitude in Sumava from 700ms in 1950s & 1980, to 1100ms in 2001 (Daniel et al 2003)
  - IR at Krkonose found at 700-750ms in 1950s & 1980s, now at 1270ms,– site not subject to change in land use for past 50 years (Materna et al 2005; Danielova et al 2006)
- Slovakia
  - Previously IR upto 800ms, now found at ~1200ms asl (Marketa Derdakova PC; Maria Kazimirova PC; Bullova et al.)

Altitudinal expansion – explanation: Climate

Increased temperatures at altitude

- Czech Republic
  - expansion due to increased temperature - prolonged questing period (Daniel et al 2004, Danielova et al 2006)
  - temp increases in spring/summer in Moravian highlands by 2.8oC – creates conditions found at lower altitudes, making higher areas more suitable for IR survival. Increased temp in Jan/Feb mean increased small mammal survival (Danielova et al 2008a, b)
  - increase in AT at 1000m from 1961-2005 by 1.4oC; increase in spring/summer temp by 3.5oC in Krkonose (Danielova et al 2008b, 2010)
  - Hungary – compared data from 1950s with 2000s – autumn activity started and ended 1 month later (Szell et al 2006)

Inter-annual differences

- Weather changes responsible for inter-annual differences. Cold winter (more overwintering due to increased snow) and very hot summer increase tick numbers. (Daniel et al 2008) – need to look at long term trends

Mode of expansion – dispersal by deer

- movement occurs as engorged ticks on hosts to sites now more favourable for tick survival (Danielova et al 2006)
- deer possibly move IR to higher altitudes: effects of temperature on vegetation period at altitude (Materna et al 2008)
- increase in deer populations facilitated increase IR at these altitudes (Zeman & Benes 2004)

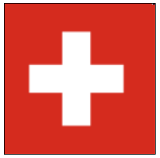
Altitudinal expansion - explanation: habitat change

- Italy (Rizzoli et al 2009)
  - Increase in temperature in Italian alps since 1980s
  - Forest & wildlife management changed
    - Forest cover increased 2.2% (1950-2002)
    - Coppice decreased 11.8%
    - High stand forest increased 10.8%
    - Forests now considered more complex ecosystem, rather than just for timber
    - All factors combine to increase habitat for ticks
  - Increase in roe deer following 1940s war
- Slovakia (Maria Kazimirova PC; Hrklova et al 2008)
  - During last 20 years areas of formerly cultivated land at altitude is uncultivated, offering new rodent and IR habitats
  - Evidence of IR in new regions at altitude

Altitude: impact on tick abundance and biological explanations

- Czech Republic
  - Danielova et al 2006: IR abundance decreased with increasing altitude.
  - Materna et al 2008: vertical transects (620-1270ms) 2002-2006
    - IR oviposited upto 1150ms
    - All eggs hatched <920ms, 33% at 1070ms
    - Greater variability in egg batches at altitude
    - 2006 (1.7oC warmer Jun-Aug): larval moulting higher – no link to rainfall

Altitude: changes with aspect



- Jouda et al 2004; Burri et al 2007; Moran Cadenas et al 2007; Gern et al 2008
- IR recorded upto 1450m asl in Switzerland
- Density of nymphs decreases with altitude on South-facing slopes; but increases with altitude on North-facing slopes. Impact of saturation deficit on S-.
- More IR on S- compared to N-facing slopes
- Burri: N-facing – Sat def stable at 1020m, levels detrimental to IR survival at lower altitudes
- Jouda: Start of IR season on S-facing slope was inversely related to altitude; not the case for end of season. No difference in peak of activity with altitude.
- Increased winter temp – earlier onset, longer development
- Deer move up to higher altitudes in spring

Altitude changes with latitude

- Italy
  - Rizzoli et al 2002 – IR less abundant >1300m
- Austria
  - Blaschitz et al 2008 – IR present up to 827ms
- Czech Republic
  - Danielova et al 2006: up to 1080m in Sumava; 1270m in Krkonose
- UK
  - Gilbert 2010 – IR present up to 550ms in Scotland – numbers decreased with altitude linked to host abundance
- Any further data available?

Lower altitudinal restrictions with changing lowland climate

- Greece: Anna Papa PC; Papa et al 2008
  - Lower altitudinal limit 600ms
- Evidence from other countries?
- Evidence of actual change in lower altitudinal limit?

Climate & Latitudinal expansion (Sweden)

- Thomas Jaenson PC; Jaenson et al 1994; Talleklint & Jaenson, 1998; Lindgren et al 2000; Jaenson et al 2009
- Shift in IR distribution in Sweden

  - shift in 1980s, 1990s; field data and questionnaire study

  - shift linked to reduction in number of days below -12oC during winter, as well as milder winter, extended spring and autumn

  - no reported changes in land use, but increase in roe deer populations
- Climatic changes lead to:

  - increased veg. period: >180d IR commonly encountered, not <160d,

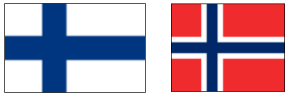
  - reduced length of snow cover: <=125d, IR consistently present, >=175d IR consistently absent

  - consequent increase and/or high densities of blood hosts – roe deer, other Cervidae (due to Scabies in fox predators, and milder winters)

  - increased range and abundance of IR

  - This relates to Mainland Sweden, Norway, Finland, also many islands: Aland archipelago, Gotska Sandon, Stora Karlso, smaller islands on coast and Stockholm archipelago – in some locations, Lepus timidus is main host in absence of cervidae

Latitudinal expansion (Finland, Norway)



Jaenson et al 1994; Talleklint & Jaenson, 1998; Han et al 2001; Jaenson & Lindgren, 2010; Kjelland et al 2010

- IR restricted to south of Finland
- Climate-based predictions that IR will expand to all regions by 2071-2100, along with expansion of deciduous woodland
- Increase in IR distribution on islands, possibly due to:
    - Climatic factors
    - Increased roe deer
    - Changes in habitat structure

Patchiness, connectivity & strains – Spain, UK

- Agustin Estrada-Pena PC; Jose Oteo PC, Medlock PC
- Long-term and short-term changes in climate suitability in Europe by modelling – increasing suitability with CC for some areas, but decreased in other sites – related to rainfall
- Habitat configuration (based on network theories) may contribute to significant changes in tick presence/abundance
- In addition to climate, host abundance and habitat patchiness - networks of habitat patches are important
  - More IR with greater connectivity between patches
  - Distance between patches & habitat fragmentation are inversely related to probability of invasion/establishment of IR
- UK – agri-environment schemes, woodland management – creating networks & more ecotones
- Strains of IR – high degree of plasticity, adaptation to regional climate. Work in press (AEP)

Expansion of tick hosts: Denmark

Per Jensen PC: roe deer population main driver of IR expansion:

- deer numbers increase 5x 1941-2000
- deer spread to new areas, tick data similar
- behavioural adaptation of RD to human disturbance
- afforestation (10-25% planned)
- change in agricultural practice (feed deer)
- scabies in foxes – decline of predators
- recent disease in deer, cause unknown
- soil type (sandy) may limit spread of deer and ticks

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Expansion of tick hosts & habitat connectivity/green cities: UK

Pietzsch et al 2005; Medlock et al 2008, Scharlemann et al 2008, Jameson & Medlock 2010, Medlock et al (in press)

- Historical data on IR published 1880-2005
- Questionnaire study showed evidence of ticks in new areas – possibly not previously recorded; 73% reporting tick increase
- Tick surveillance 2005-2009 showed significant expansion in SW England, possibly linked deer. Roe deer have expanded in SW over recent years.
- Habitats include grasslands, as well as woodlands. Deer are important in sustaining populations
- More reports of IR in peri-urban areas, gardens – network of green corridors, urban expansion, increased urban deer
- Woodland management strategies for biodiversity may promote tick survival and tick abundance; environmental change

Increased abundance of tick hosts

- Germany (Schwarz et al 2007)
- Field studies on abundance of questing ticks was related to:
  - Increasing temperatures
  - Soil moisture content
  - Vegetation type
  - Increasing wild boar population (roe deer population has remained stable)

Using tick-bite data as proxy for changes in IR dist/abundance

- Netherlands: Hofhuis et al 2006; Weilinga et al 2006; Gassner et al 2010
- No historical data
- Increase in tick bites on humans – possible increase in IR, hard to quantify
- Five year study showed increase in IR abundance – linked to degree of litter
- Possible contributory factors:
  - Expansion of nature reserves
  - Increased abundance of wildlife
  - Reduction of pesticides in agriculture and forestry
  - Climate change
- Is this evidence of spread, or just abundance? (Q to Dutch colleagues)

Anthropogenic factors

- PC: Olivier Plantard, Jean-Claude George, Karen McCoy
- France
  - IR present throughout the country (except Med; High altitude) in most forests.
  - No specific studies tracking spread
  - Increase of IR acknowledged,
  - Numerous factors centred on human-activity may contribute to destabilising a well-balance ecosystem:
    - Natural
    - Social
    - Anthropogenic

Anthropogenic factors

- Portugal – Maria Margarida Santos Silva PC
  - Increase in studies on epi of TBD; Increased pathogen testing = increased occurrence IR
  - Changes in land management
  - Pest control strategies
  - Extensive destruction of habitats by fire
  - Increase in hunting

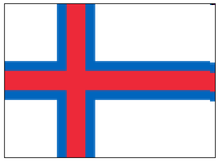
  All contributed to change in distribution
  - Also Increase in roe deer, and their re-introduction
  - Also climatic factors = possible retraction in latitudinal range to C and N Portugal

  Picture still incomplete, but studies ongoing

Urban green issues

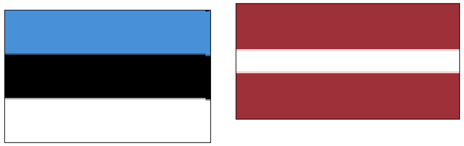
- Korenberg 2009: Green areas in cities are providing new habitats for ticks. Example from St. Petersburg
- UK – garden tick issues

Expansion to new territories (?)



- Faroe islands
  - Jens-Kjeld Jensen PC; Jaenson & Jensen 2007:
    - First record of IR on dog in 1990
    - Nymph on wheatear, 2000
    - Engorged female on cat, 2004
    - Engorged larvae on chiffchaff, 2004,
    - Nymph on human, 2005
    - Further investigations required….

No evidence of changes



- Estonia: Irina Golovljova PC: nationwide distribution of IR – no evidence of change in distribution, no specific studies
- Latvia: PC Antra Bormane, Vanwambeke et al 2010: No evidence that IR spread to eastern areas. Timber industry may play a role – natural/artificial forest re-growth could result in varying habitat quality. Clear felling could reduce habitat

Secondary tick issue (?)

- Turkey (Gargili et al 2010, Gargili et al 2011, Vatansever et al 2008)
  - 10% of ticks collected from people IR, upto 50% in some areas
  - Istanbul, 25% of ticks on humans: IR

Limited/no information

- Iceland (Lindroth et al 1973) – IR is present
- Ireland (Gray 2008) – IR is present / abundant
- Austria (Blaschitz et al 2008) – IR present up to 827ms
- Slovenia (Knap et al 2009) – IR present up to 857ms
- Belgium (?), Andorra (+), Malta (-), Cyprus (-) – Estrada-Pena PC
- Lithuania (?), Luxembourg (?)
- Other countries….

Conclusions

- Each country is different; general lack of field-based evidence, however enough evidence to suggest dramatic recent shifts
- Combination of factors
  - Temperature changes
  - Shorter/milder winters
  - Movement of tick hosts
  - Habitat connectivity
  - Changes to farming, forestry
  - Urban green corridors
  - Anthropogenic factors – greater awareness, human behaviour, impacts on land use
- Evidence – at the extremes
  - Higher altitude
  - Higher latitude
  - Islands
- Need for empirical data – economically viable options – discuss?

Hyalomma – driving forces for change

- Case study in Kosovo (Jameson & Medlock, in prep)
- Rise & decline of agriculture
  - Since 1960s, deforestation for agriculture
  - Decline in habitat for *Ixodes/Dermacentor*, more habitat for *Hyalomma*
  - Conflict 1990s, decline in agriculture, reduction in herbicide use
  - Less land now in production
  - Arable land acting as buffer between village/grazed grasslands now removed. Increased exposure/awareness of *Hyalomma*; shift in local geographic range

Hyalomma – driving forces for change

- <u>Influence of livestock</u>
  - Following conflict, large importation of naïve cattle from Europe to replenish stocks
  - Indigenous breeds more resistant to external parasites
  - Increased biting rates, possible co-feeding
  - CCHF endemic areas similar to areas with high proportion of cross-breeds
  - Cross-breeds favoured for higher milk yields
  - Consequently more *Hyalomma*
  - Tick removal from cattle is not routine

Hyalomma – driving forces for change

- Influence of wildlife
  - Hunting was heavy prior to 1990s
  - Banned during/after conflict
  - Large increases in wildlife numbers
  - Hare populations have increased dramatically in some areas (important tick host, and virus reservoir)
  - Possible link to decline in prey (rabies in fox)
  - Imbalance in predator-prey cycle
- Influence of humans
  - Since 1990s, rural population has increased
  - 60% employment in agriculture
  - Tick-bite prevalence on the increase

Your expertise is required!

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- Next steps
  - Circulate summary of IR drivers
  - Circulate IR factsheet
  - Receive contributions on HM – Thanks to those who have already offered contributions. JM and/or LJ will be emailing shortly

Thank you